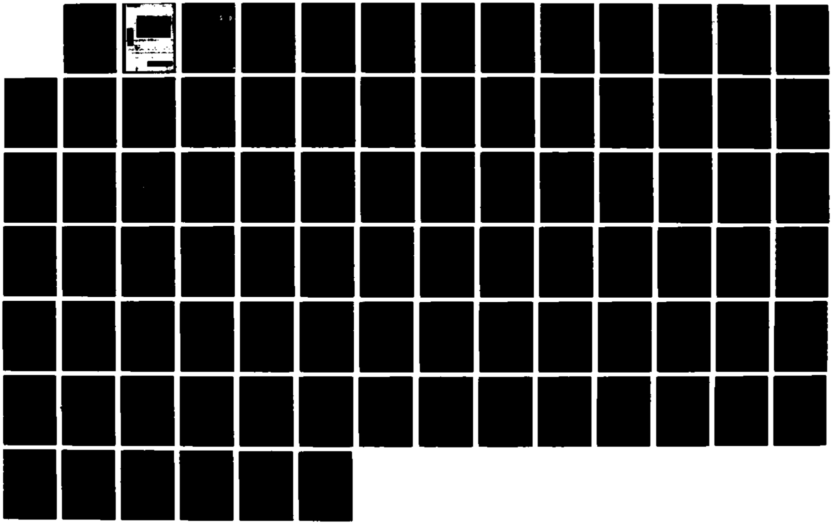
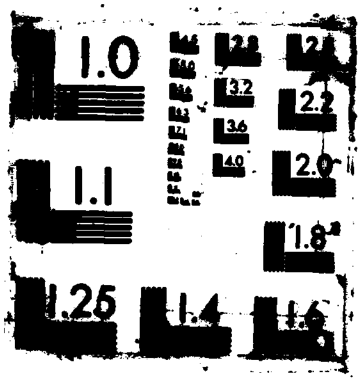
AD-A187 796 MEASUREMENT OF FORCES AND MOMENTS ON AND VELOCITY ABOUT 1/1
A BODY OF REVOLUT..(U) MASSACHUSETTS INST OF TECH
CAMBRIDGE DEPT OF OCEAN ENGINEERIN.. J S REED JUN 87
UNCLASSIFIED N00228-85-G-3262 F/G 20/4 NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

DTIC FILE COPY

AD-A187 796

DEPARTMENT OF OCEAN ENGINEERING

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS 02139

(1)

MEASUREMENT OF FORCES AND MOMENTS ON, AND VELOCITY ABOUT A BODY OF REVOLUTION WITH AN ATTACHED FIN AT ANGLES OF ATTACK

by

Jeffrey S. Reed

XIII-A

JUNE, 1987

87 11 16 077

(1)

MEASUREMENT OF FORCES AND MOMENTS ON, AND VELOCITY ABOUT A BODY OF REVOLUTION WITH AN ATTACHED FIN AT ANGLES OF ATTACK

by

Jeffrey S. Reed

B.S., United States Naval Academy
(1980)

SUBMITTED TO THE DEPARTMENT OF OCEAN ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREES OF

NAVAL ENGINEER

and

MASTER OF SCIENCE IN NAVAL ARCHITECTURE AND MARINE ENGINEERING

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 1987

N00228-85-G-3262

Signature of Author: ______________________
Department of Ocean Engineering
June 1, 1987

Certified by: ______________________
Professor Justin E. Kerwin
Thesis Supervisor

Accepted by: ______________________
A. ~~Douglas~~ Carmichael
Chairman, Ocean Engineering Departmental Committee

MEASUREMENT OF FORCES AND MOMENTS ON, AND VELOCITY ABOUT A BODY OF REVOLUTION WITH AN ATTACHED FIN AT ANGLES OF ATTACK

by
Jeffrey S. Reed

Submitted to the Department of Ocean Engineering on May 8, 1987 in partial fulfillment of the requirements for the degrees of Naval Engineer and Master of Science in Naval Architecture and Marine Engineering.

ABSTRACT

The body of revolution had a length to diameter ratio of 9.5 and was tested with a square tipped and a round tipped fin. A two component strain gage balance was used to measure the force and moment on the fins. Laser doppler velocimetry techniques were used to measure velocity contours about the body and fin.

Strain gage data was plotted for various angles of attack and Reynolds numbers ranging up to 5 million based on the chord length of the fin. These curves were combined to obtain lift versus angle of attack data for the two fins. From the laser velocity data, velocity plots were generated to verify location of vorticies. Numerical integration of the laser velocity data yielded circulation values for the velocity contours. Circulation, forces and theory are compared.

Coefficient of lift versus angle of attack for the two fins, circulation values at various radii from the body, circulation values at various spans on the fin, and comparisons between the methods are presented.

Thesis Supervisor: Justin E. Kerwin
Title: Professor of Naval Architecture

ACKNOWLEDGMENTS

The author wishes to thank Professor Kerwin for his guidance throughout this project, Lori Fretz for her many hours of collecting data, and S. Dean Lewis for his invaluable assistance, especially during the design, construction, and installation of the model.

Many thanks go to my two contacts from Electric Boat, the project's sponsor: Jerry Fridsma and Chuck Henry. They provided moral, financial, and technical support.

A special thanks goes to my wife, Debbi for her tireless support, patience and understanding throughout the project. The last thanks, because it should be, goes to the other two Amigos who helped me keep a sense of humor and perspective throughout the project.

Table of Contents

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Several types of ocean vehicles that operate fully submerged can be modelled as a body of revolution with an attached fin. Placing the model at an angle of attack to a free stream simulates the flow about the ocean vehicle in a turn. At an angle to the free stream, an unappended body of revolution will develop two symmetric body vortices on the lee side, similar to those developed by a cylinder in a crossflow. When a fin is appended to the body, a third vortex, shed from the tip of the fin, is introduced into the flow. Figure 1 depicts the vortex pattern about the appended model. This third vortex destroys the symmetry of the unappended body, and greatly affects the maneuvering characteristics of the vehicle. The motions of undersea vehicles are generally controlled by lifting surfaces placed near the stern. The forces generated by these surfaces are greatly affected by their incident flow. To accurately predict the maneuvers of a submerged vehicle, the strength of the vortex system must be known.

Direct measurements yielded the strength of the forces and moments on the fin. Integrating the velocity data taken on various contours gave circulation values. The circulation values provided the forces on the body

using the Kutta-Joukowski thereom. These forces must be counter-acted by the aforementioned control surfaces. This data will aid in improving and validating computer models which predict flow patterns about a submerged vehicle as it maneuvers and aid the designers of undersea vehicles.

CHAPTER 2

EXPERIMENTAL APPARATUS

This experiment was conducted at the Massachusetts Institute of Technology using the Marine Hydrodynamics Laboratory's variable pressure water tunnel and two component Laser Doppler Velocimetry (LDV). A complete description of the test facility LDV techniques can be found in Min, Kobayashi, Sayre, or Coney [1-4].

The LDV system is basically the same as described by Kaplan [5] except the laser and optics were arranged for two components. The 488.0 nano-meter wavelength blue beam measured the horizontal component of velocity. The 514.5 nano-meter wavelength green beam was used to measure the vertical component of velocity. Due to the increased complexity of the optics, the laser could no longer be rotated. The laser and optics were mounted on a computer controlled traverse table system.

To obtain the forces and moments on the fin, an instrumented balance was installed in the model. The lower flange of the balance was counter-sunk into the body. The hollowed fins were bolted to the top flange of the balance. The balance's strain gage wires were run out the stern of the body, through the sting and out cableways which were bored in the support device to the signal conditioner The sting allowed four discrete

angles of yaw: 4 degrees, 9 degrees, 14 degrees, and 20 degrees. Hereafter, the 14 degree angle will be referred to as 15 degrees to be consistent with Kaplan [5]. The support device allows laser velocity measurements to be taken on contours which go completely around the model. The support device is similar to that described by Kaplan [5] except the diameter of the sting was increased from 0.688 inches to 1.25 inches. This increase was to reduce the vibrations experienced by Kaplan at high test speeds. Vibrations were also reduced by decreasing the mass of the body by boring a 1" diameter cableway. The benefits of the stiffer model and sting were threefold: 1) more reliable sampling close to the body, 2) no stalling of the fin at reasonable Reynolds Numbers and angles of attack, and 3) no change in angle of attack due to water velocity. Figure 2 shows a shear plan of the balance beam installation.

The sting mounted model was a body of revolution with a length to diameter ratio of 9.5. The maximum diameter of the model was 2.695 inches. Both fins were NACA 0022 sections with a chord length of 2.053 inches and a planform area of 3.42 square inches. The leading edge was 6.092 inches from the bow. The round tipped fin had a maximum span of 1.719 inches. The square tipped fin had a span of 1.666 inches. Appendix 1 contains a detailed description of the model and fins.

CHAPTER 3

DATA ACQUISITION

The force, moments and free stream velocity were measured using sampling routines contained in the program in Appendix 2. The data was sampled over a period of 30 seconds. The forces and moments were measured on the fin over a range of Reynolds numbers from 1.0 x 10^4 to 4.5 x 10^5 based on the fin's chord length. Data runs were made both increasing and decreasing water velocity. Data runs were made at three angles of yaw: 4 degrees, 9 degrees, and 15 degrees. Data runs were not made at 20 degrees of yaw because flow visualization revealed the fin was stalled at all Reynolds numbers at this angle of yaw. All data runs were done with both the square tipped fin and the round tipped fin.

To perform the body velocity measurement contours, two coordinate systems and a body rotation system, as defined in Figures 3 and 4, were used. The model coordinate system (X_M, Y_M, Z_M) was fixed with the rotating model, while the laser coordinate system (X_L, Y_L, Z_L) was fixed in space. The origin for both coordinate systems was the point about which the model rotated in the tunnel. This origin provided a convenient reference for conducting coordinate transformations. The model rotation was defined to be zero when Y_M and Z_L coincided.

The origin was established using the focal point of the laser, the computer driven digital traverse, and the known geometry of the model. A procedure similar to Kaplan's [5], except for the different laser coordinates, was used. The laser coordinates and fluid velocity of each point on the contour were calculated using a coordinate transformation and a sampling routine. The program, contained in Appendix 3, required the radius of the contour, the degree increment of rotation, and the distance from the bow to be input. The program would then compute the laser coordinates. The traverse was positioned using an IBM PC/XT. The vertical component of velocity and freestream velocity were sampled and averaged over 20 seconds. The vertical component of velocity gave the tangential component of velocity on the circular body contour. The program then recorded body coordinates, body rotation, laser velocity, freestream velocity, and velocity ratio. This procedure was repeated for each body velocity contour. Body velocity contours were taken 0.35 inches, 1.0 inches, and 2.2 inches from the body. All body velocity contours were taken 12.92 inches from the bow; the same X_M location as both coordinate systems' origins. This station location was chosen to reduce any errors which would be caused by model installation misalignments and body rotation eccentricities.

The fin velocity contours were taken using two coordinate systems: a fin coordinate system (X_F, Y_F, Z_F), and a laser coordinate system (X_L, Y_L, Z_L). Both systems were fixed in space, since the body was at a constant 90. degree rotation. The origin of both systems was at the leading edge of the tip of the fin. Rectangular contours as shown in Figure 6 were taken with the following insets from the tip: 0.2 inches, 0.45 inches, 0.7 inches, and 1.2 inches. The programs for each of the legs are in Appendix 4.

All velocity contours were taken with a water velocity of approximately 25 feet/second. This velocity equates to a Reynolds number of 5.5 X 106 based on the length of the model, or a Reynolds number of 4.4×10^5 based on the chord length of the fin. To insure that a turbulent boundary layer was present, a trip was placed around the nose. Relationships presented by Tani [6], were used to determine the location and character of the trip necessary to cause turbulent flow at the trip. A strip of electric tape 0.125 inches wide and 0.007 inches thick was placed 0.77 inches aft of the bow. A trip was not placed on the fin, since flow visualization revealed flow would stay attached through a broader range of Reynolds numbers without the trip.

CHAPTER 4

DATA ANALYSIS

When force, moment, and velocity measurements were completed, the fin lift coefficients were non-dimensionalized on freestream velocity and fin planform area. The moment coefficient was non-dimensionalized on an additional chord length and had an origin 0.19 inches above the intersection of the fin and the body. The force and moment data were used to determine the center of pressure on the fin. The force data was plotted on a Tektronix 4662 plotter. The fortran code for the general purpose plotting routine is in Appendix 5.

The body velocity contours were plotted on the same plotter using the source code in Appendix 6. Simpson's rule was used to integrate the body velocity contours to get circulation. The circulation was non-dimensionalized on the body's maximum diameter and freestream velocity.

The fin velocity legs, at each inset, were integrated using trapezoidal integration. The values of the four legs at each inset were added to get the circulation value for the contour. To compare circulation measurements to the force and moment measurements, a circulation value of 0.0 was assigned to the tip; linear extrapolation was used to get a

circulation value at the root. This extrapolated circulation distribution was integrated using trapezoidal integration. Once again the circulation was non-dimensionalized using the body's maximum diameter and the freestream velocity.

CHAPTER 5

RESULTS

The force, moment, and freestream velocity data are contained in Appendix 7. The three angles of yaw were 4 degrees, 9 degrees, and 15 degrees. Since flow visualization revealed the fin was stalled at 20 degrees of yaw, no measurements were taken at 20 degrees. Comparable runs were made for both the square tipped and round tipped fin. Figures 7-9 contain the plots of lift coefficient versus Reynolds number for the square tipped fin at the three angles of attack. Figures 10-12 contain the analogous plots for the round tipped fin. The square tipped fin's lift coefficient has an apparent Reynolds number dependency throughout the range tested. Figure 7 shows the hysteresis of stall in the loop between Reynolds numbers of 0.5 X 105 and 2.0×10^5. The round tipped fin does not have Reynolds number dependency above a Reynolds number of 2.0×10^5. This trend was true for all three angles of yaw. The force and moment data were used to calculate the center of pressure for the round tipped fin for the three angles of yaw. The center of pressure results were non-dimensionalized on the chord length of the fin and are presented in Table 1. The center of pressure was not calculated for the square tipped fin because of its lift Reynolds number

dependency. The data for the round tipped fin was combined in Figures 13 and 14 to yield lift versus angle of attack data. The slope of the curve in Figure 14 is 0.043 over the linear range.

The body velocity contours were taken 12.92 inches aft of the bow. This station coincides with the origins of the laser and model coordinate systems. This station choice minimized any errors due to body positioning or eccentricity of body rotation. The round tipped fin was used for all body velocity contours, since it's coefficient of lift was independent of Reynolds number at the test speed of 25 feet/second. Appendix 8 contains the body velocity contour data. The contours were taken at the following stand-offs from the body: 0.35 inches, 1.0 inches, and 2.2 inches.

The tangential velocities are plotted against body rotation in Figures 15-17. A rotation of 0. degrees is on the port beam; a rotation of 90. degrees is top dead center, or aft of the fin. Figure 15 shows the strong keel vortex described by Kaplan [5]. This vortex causes a high velocity region between 270. and 330. degrees of body rotation. Figure 16 shows the velocity peak due to the fin's tip vortex at a rotation of 70. degrees. This plot agrees with flow visualizations which revealed that this vortex was convected downstream and slightly towards

the body. The influence of the keel vortex was considerably weaker as the contours move farther away from the body, as shown in Figure 19. The fin's tip vortex was still evident in Figure 17. However the sign of the velocity had changed, which indicated the contour had moved to the opposite side of the vortex, the two contours are combined in Figure 18. This sign change provides a quick and easy method of locating vortices. The weaker deck vortex described by Kaplan [5] is not clearly evident in any of the body velocity contours. However, a close comparison with Kaplan's [5] vector plots, revealed that a very weak deck vortex may have been at a rotation of 70. degrees in Figure 15. Figure 20 shows the location of the three vortices based on both the body velocity contours and the vector plots. The cross indicates the center of the vortices and the arrow their direction. The strength of the deck vortex was <u>much</u> less than the keel and tip vortices.

The tangential velocity was integrated using Simpson's rule to get circulation. The values are presented in Table 1. The contour with 2.2 inches stand-off verified Kelvin's thereom to within 3.8 percent of the maximum values measured. The 0.35 inch stand-off and 1.0 inch stand-off contours are amazingly close and indicated that no major vortices are between these two contours.

The data for the fin velocity contours are presented in Appendix 9. The rectangular contours were taken at four insets from the tip: 0.2 inches, 0.45 inches, 0.7 inches, and 1.2 inches. Velocity contours were attempted closer to the body, but velocity measurements were inconsistent even after being averaged over 20 seconds. Using trapezoidal integration, the velocity contours at each inset were integrated to get circulation. The circulation values are also presented in Table 1. Heavier loading was apparent near the root while tip was more lightly loaded.

Using potential theory [7], lifting line theory, as presented by Kerwin [8], and Wald's [9,10] methods, the three dimensional lift coefficient can be calculated to be 0.758. These theoretical lift coefficient calculations are presented in Appendix 10. The lift coefficient from the force and moment measurements for this configuration was 0.538. Using linear extrapolation at the root and assigning a zero circulation value at the tip, yielded a circulation distribution for the fin and a lift coefficient of 0.552. This calculation revealed a 2.6 percent difference between the direct force and moment measurements and the integration of the fin velocity contour measurements. The three lift coefficients are presented in Table 1. Stall, as seen in Figure 14 at high angles of attack, may be the reason the

measured coefficients are lower than the theoretical value.

Table 1.
[15 Degrees Yaw Angle]

CENTER OF PRESSURE
ROUND TIPPED FIN

Yaw (Degrees)	Center of Pressure (non-dimensional)[1]
4.0	0.355
9.0	0.372
15.0	0.391

BODY CIRCULATION VALUES

Stand-off (inches)	Circulation (non-dimensional)[2]
0.35	0.262
1.00	0.261
2.20	-0.010

FIN CIRCULATION VALUES

Stand-off (inches)	Circulation (non-dimensional)[2]
0.00	0.000[3]
0.20	0.098
0.45	0.238
0.70	0.276
1.20	0.282
1.72	0.288[3]

LIFT COEFFICIENTS

Method	C_L[4]
Theoretical	0.758
Direct Force Measurement	0.538
Circulation	0.552

1 Non-dimensionalized on chord length, origin at fin's root.
2 Non-dimensionalized on maximum diameter and freestream velocity.
3 Extrapolated value.
4 Non-dimensionalized on fin planform area and freestream velocity.

CHAPTER 6

DISCUSSION

The new design sting and quadrant allowed higher test speeds, reduced vibrations, eliminated the fin's stalling at 15 degrees yaw, and precluded measurable angle of attack changes due to deflections caused by water velocity. Using an instrumented balance in the fin, provided direct and reproducible force and moment measurements . The method of taking body velocity contours eliminated the problems described by Coney [4] and Kaplan [5]. Repeated body velocity contours can be used to reliably locate vortices so that the exact path of the contour relative to the vortices can be determined. The velocity contours can be integrated to get accurate circulation measurements; Kelvin's Thereon was verified to within experimental error at the outer contour. The fin velocity contours were integrated to provide circulation accurately. The fin circulation values checked within experimental accuracy with the direct force measurements, and theoretical calculations which used lifting line and potential flow theory.

The force and moment measurements revealed a difference in Reynolds number dependency for lift between the two fin geometries. The difference could be attributed to two factors, either the difference in fin

geometries or the square tipped fin's larger gap between the root and the body. To determine the exact cause, the square tipped fin should be re-machined so the two gaps are the same.

The body velocity contour method provides a more direct, and quicker method of finding vortices and measuring circulation than previous methods. To measure closer to the body and inside the deck and keel vortices, the backscatter or flare off the body must be reduced. Painting the body a fluorescent color, might prevent this backscatter from passing through the filters.

The integration of the fin velocity contours provided accurate verifiable circulations. Future measurements need to be taken closer to the tip and root to verify the extrapolations used to determine the fin's circulation distribution. Another viable hypothesis, which would support the horseshoe vortex theory [5], would be to extrapolate the root circulation to the body circulation value obtained with the body contours.

Had all of the data analysis methodology been fully developed and refined at the time testing, more revealing measurements could have been conducted. Specifically, better body and keel vortex mapping, so contours could verify the vortices' strength and check the horseshoe vortex theory presented by Kaplan [5]. The methodologies developed provide the means to relatively quickly resolve

and verify successively more detailed aspects of the flow around a body of revolution with an attached fin at angles of yaw.

REFERENCES

1. Kobayashi, S. "An Experimental and Theoretical Study of Marine Propeller Boundary Layer Characteristics." PhD thesis, M.I.T., Department of Ocean Engineering, 1981.

2. Min, K.S. "Numerical and Experimental Methods for the Prediction of Field Point Velocities around Propeller Blades." PhD thesis, M.I.T., Department of Ocean Engineering, 1978.

3. Sayre, C.H. "Laser Doppler Anemometry and the Measurement of Loading Characteristics of Lifting Sections." MS thesis, M.I.T., Department of Ocean Engineering, 1980.

4. Coney, W.B. "Circulation Measurements About a Body of Revolution with an Attached Fin." MS thesis, M.I.T., Department of Ocean Engineering, 1985.

5. Kaplan, J.F. "Velocity Measurements About a Body of Revolution with and without a Fin at Angles of Attack." MS thesis, Department of Ocean Engineering, 1986.

6. Tani, I. "Boundary-layer Transition." <u>Annual Review of Fluid Mechanics</u>, 1969, Vol. 1. p. 186.

7. Newman, J.N. <u>Marine Hydrodynamics</u>. The MIT Press, Cambridge, MA USA 1977.

8. Kerwin, J.E. "Hydrodynamic Theory for Propeller Design and Analysis." M.I.T. course 13.04 Lecture Notes. Spring 1986.

9. Wald, Q. "The Hydrodynamic Forces on Fin-Body Combinations." Electric Boat Division of General Dynamics, Report No. P-411-67-077, Proprietary. December 1967.

10. Wald, Q. "Practical Formulas for the Stabilizing and Control Forces due to Fins on Bodies of Circular Section." Electric Boat Division of General Dynamics, Report No. TR-sc-84/22, Proprietary. November 1984.

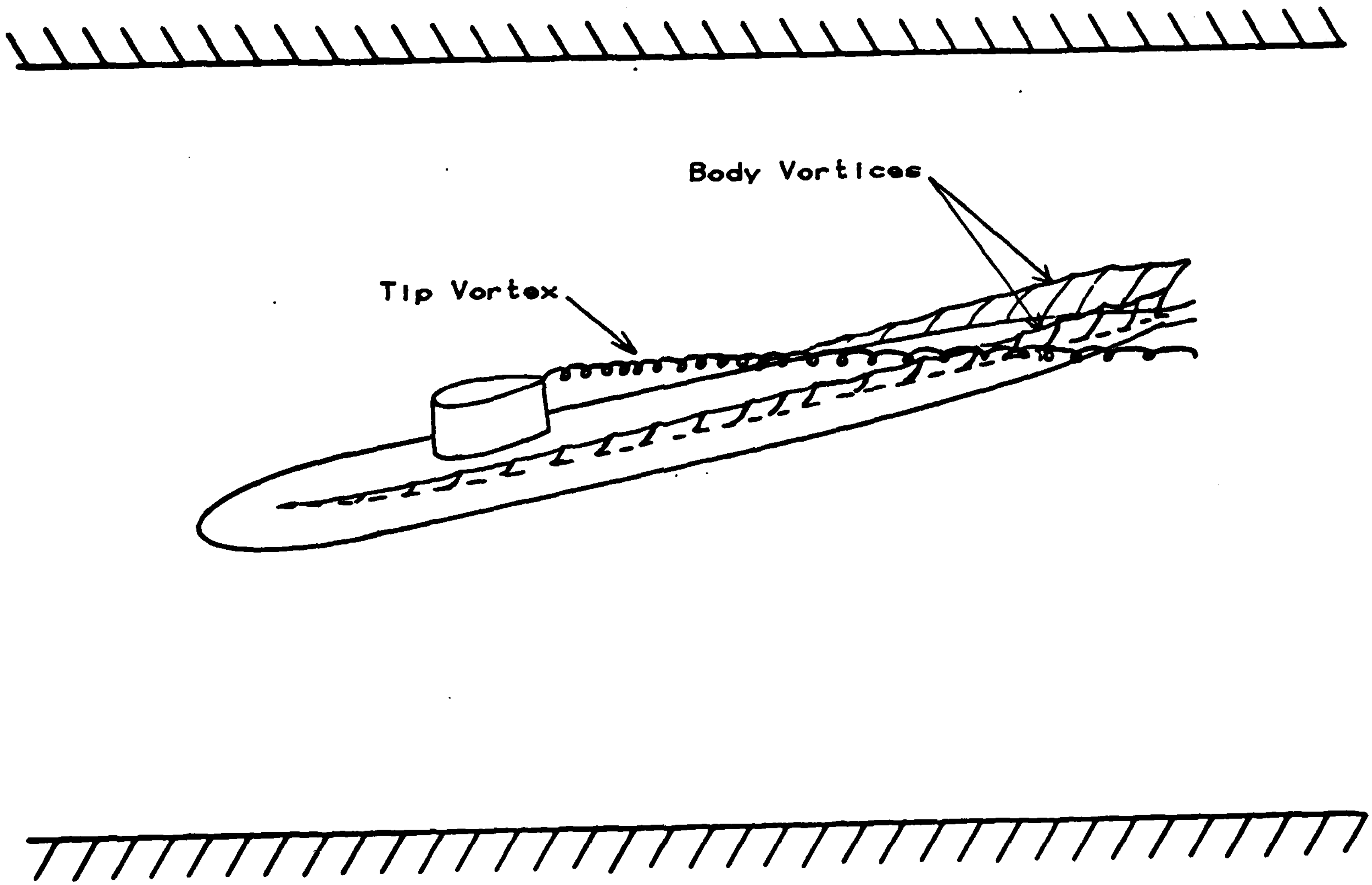
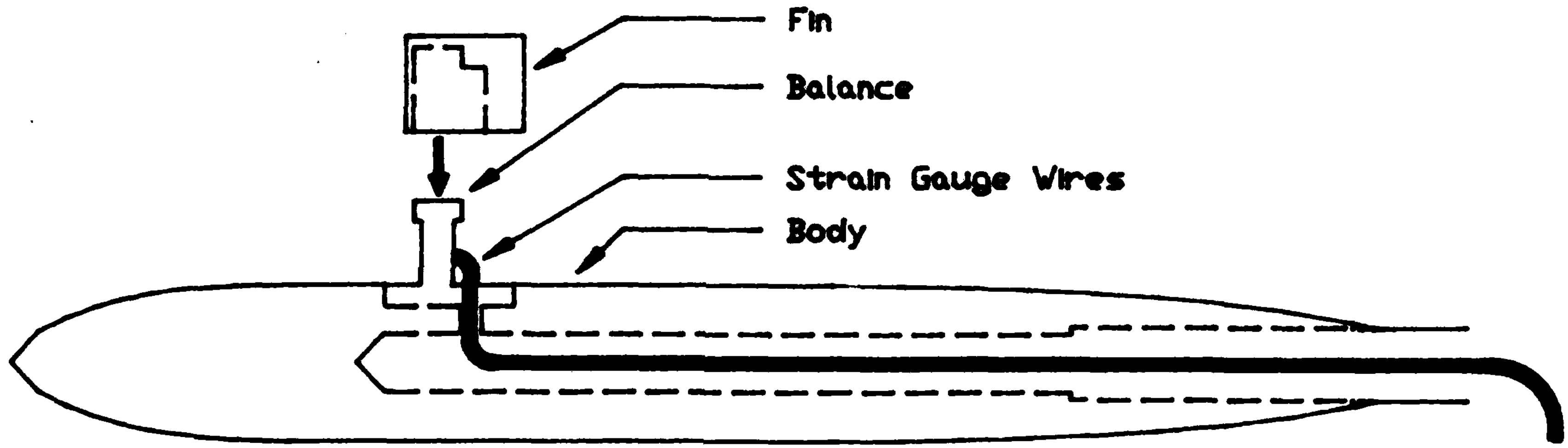
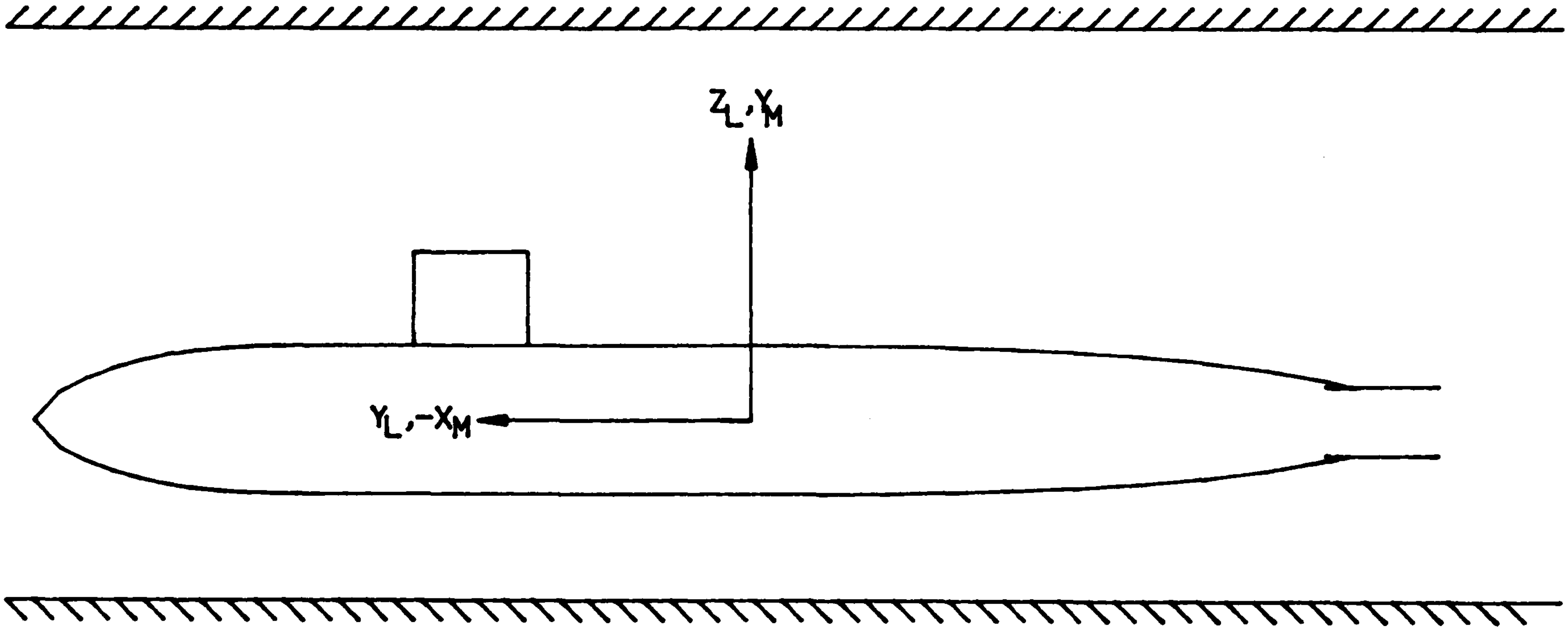


Figure 1. Flow Visualization Model



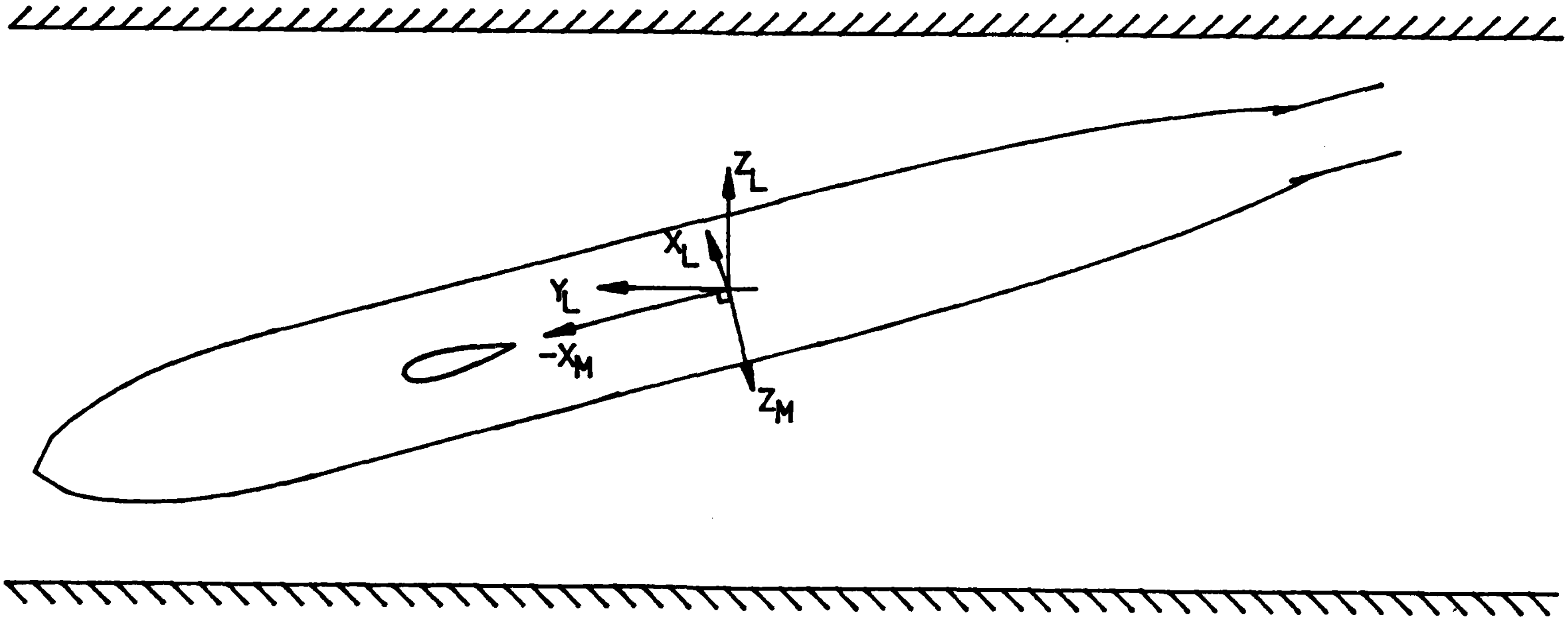
Balance Installation

Figure 2.



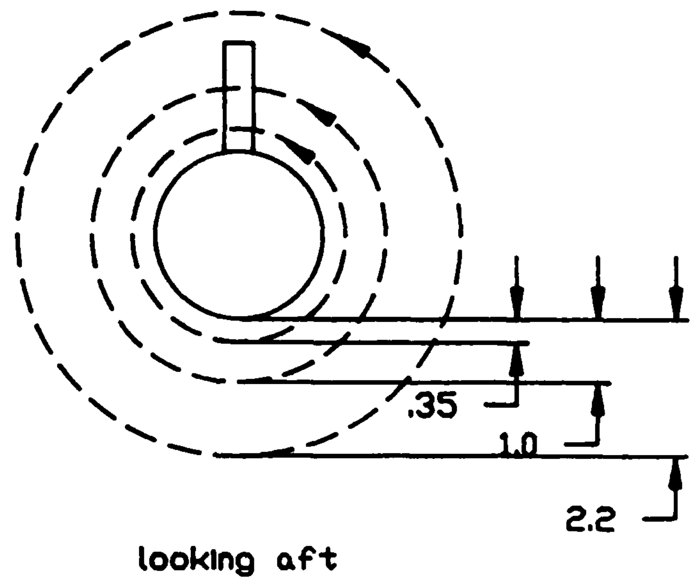
Side View Rotation=0°

Figure 3.



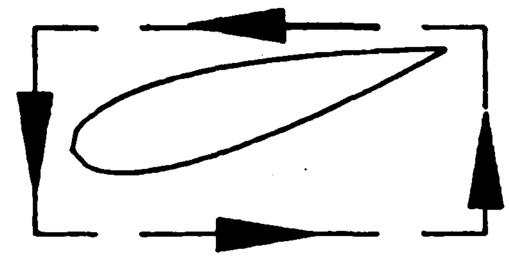
Side View Rotation=90°

Figure 4.



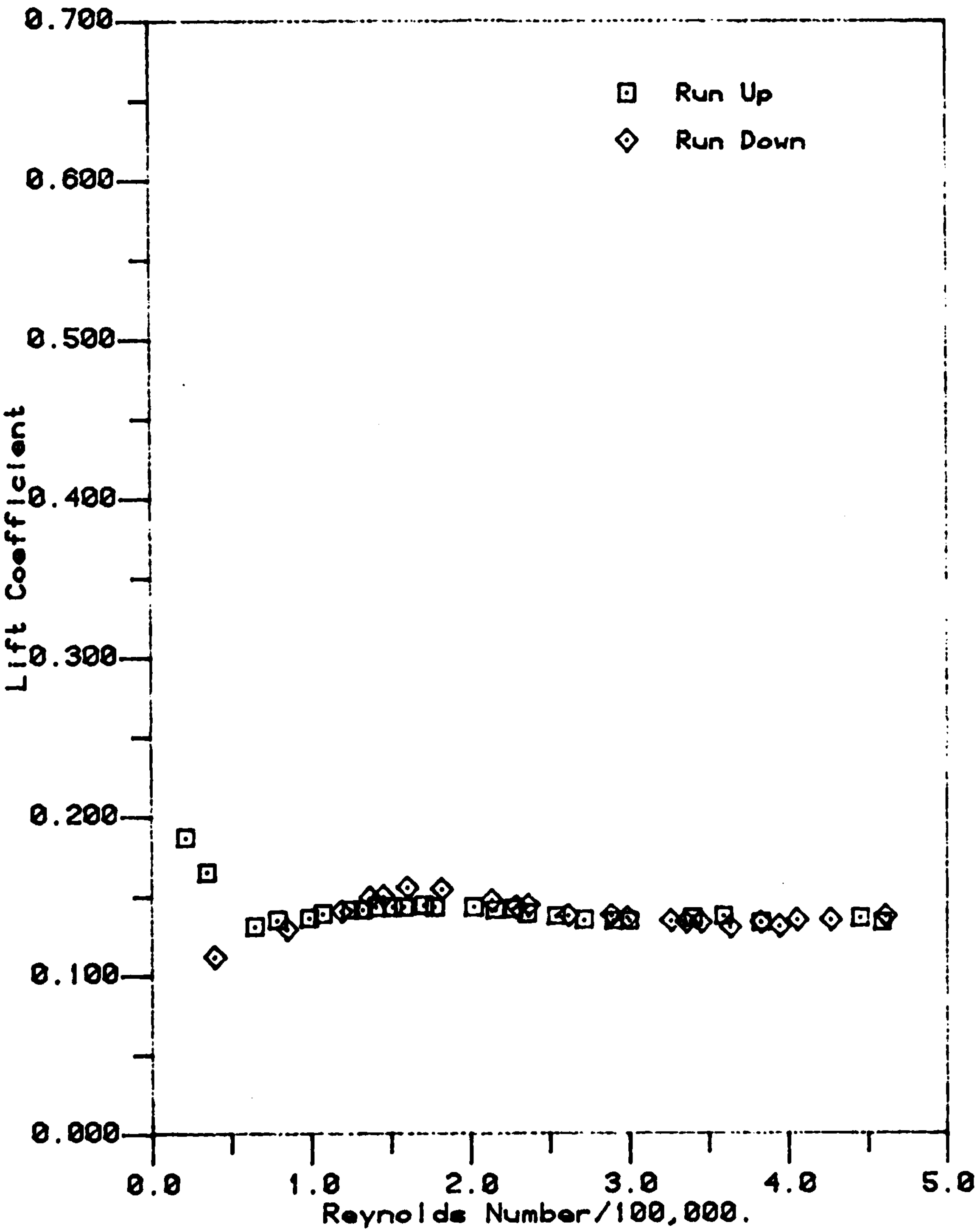
Body Velocity Contours

Figure 5.



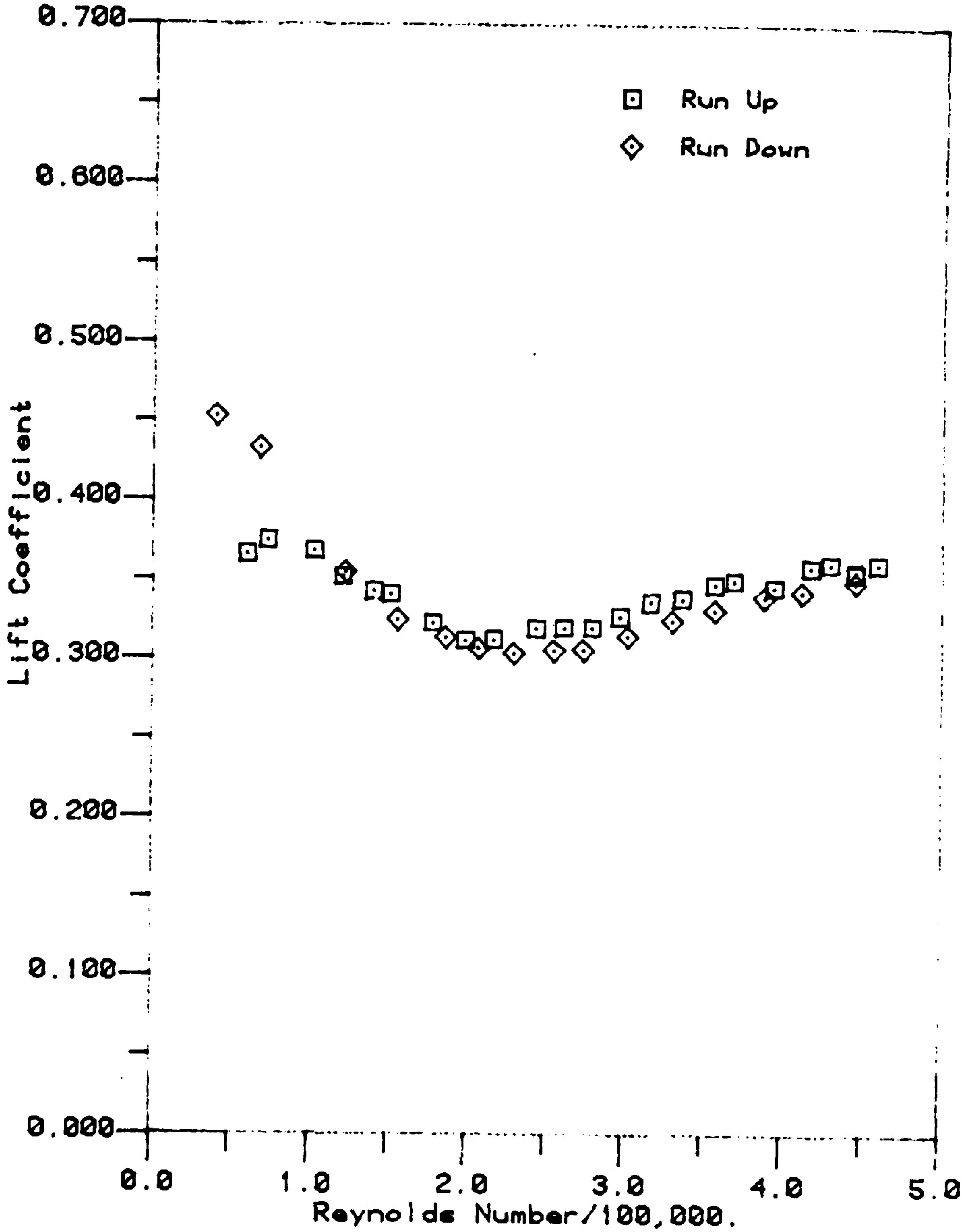
Fin Velocity Contour

Figure 6.



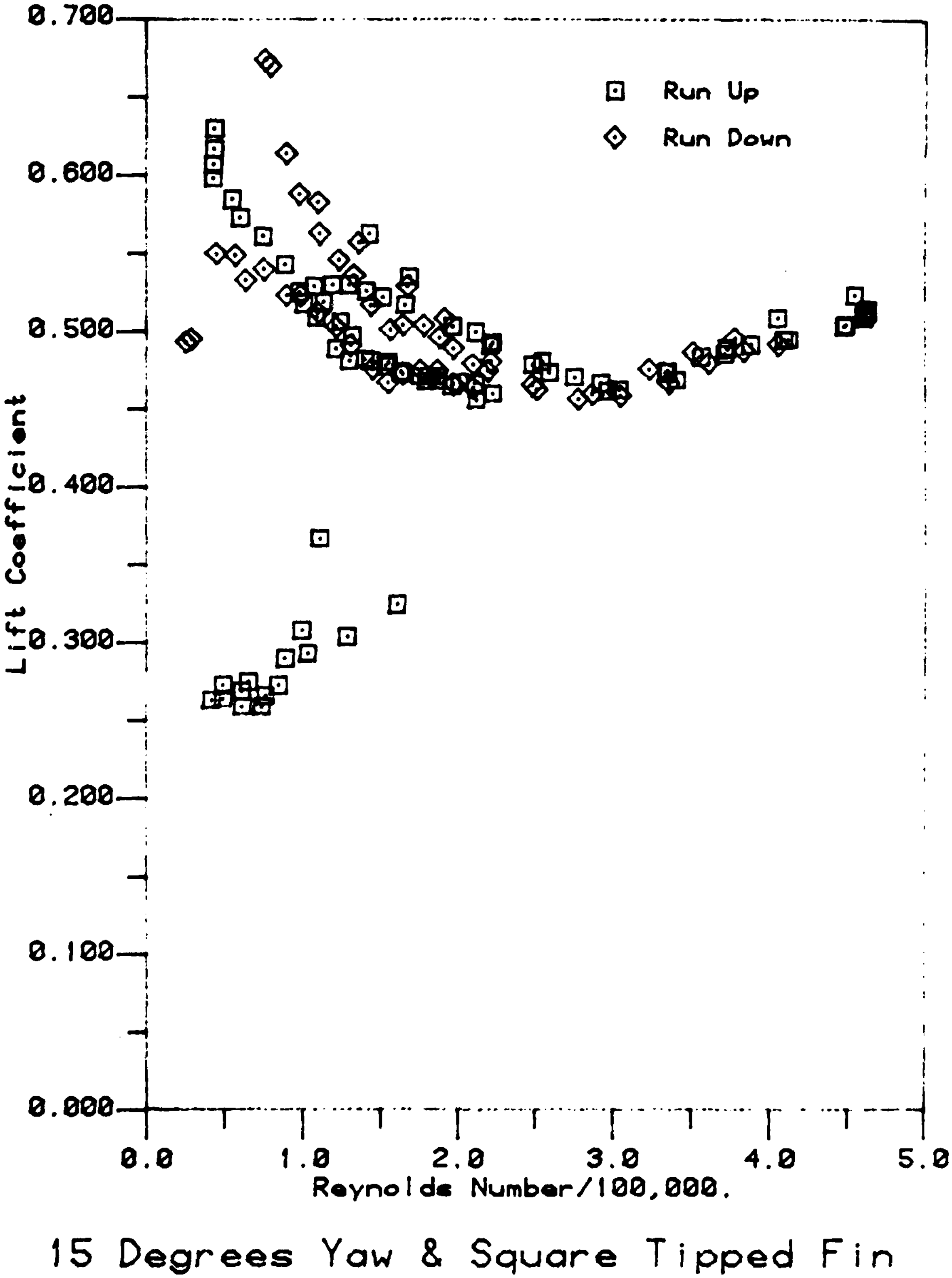
4 Degrees Yaw & Square Tipped Fin

Figure 7.



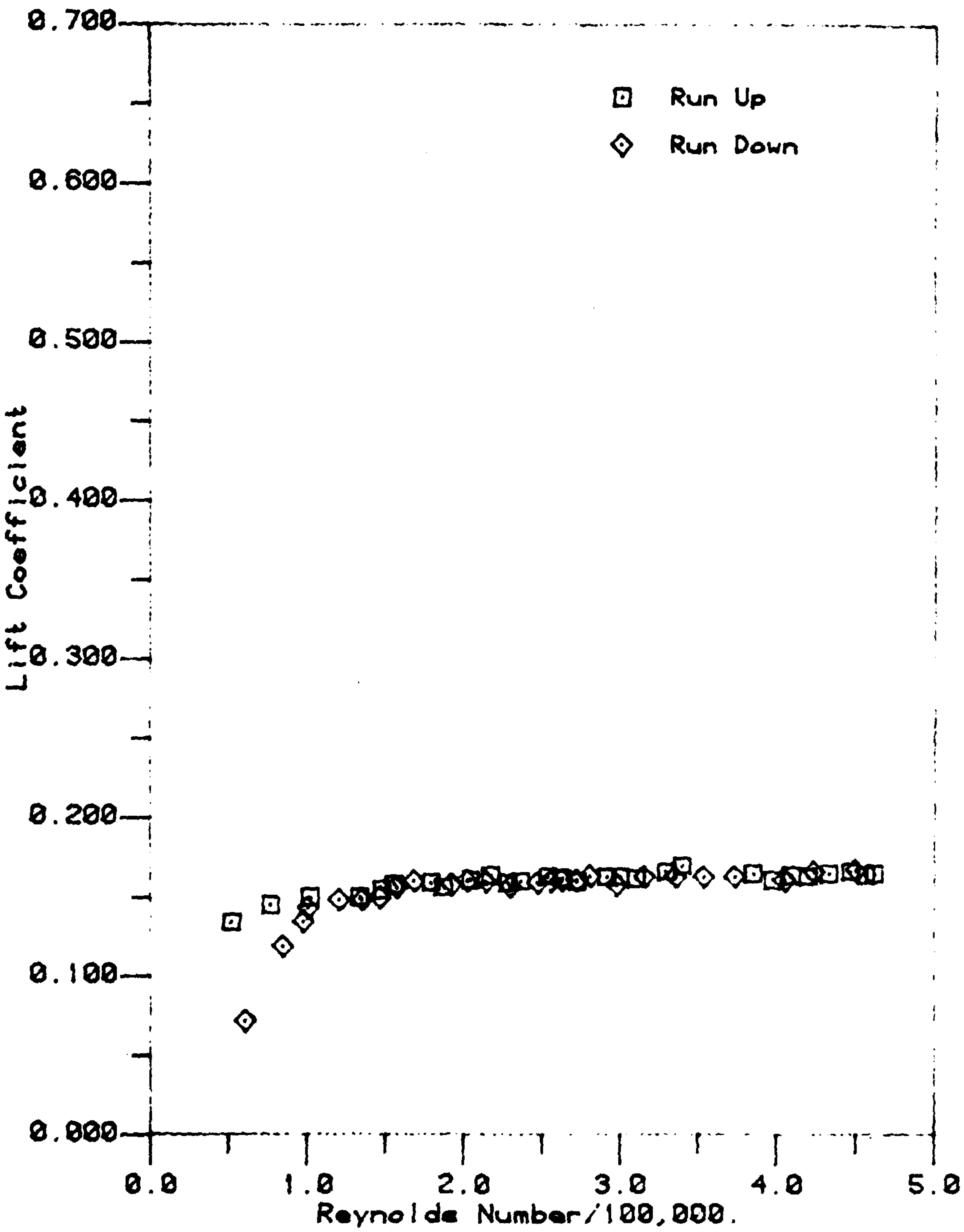
9 Degrees Yaw & Square Tipped Fin

Figure 8.



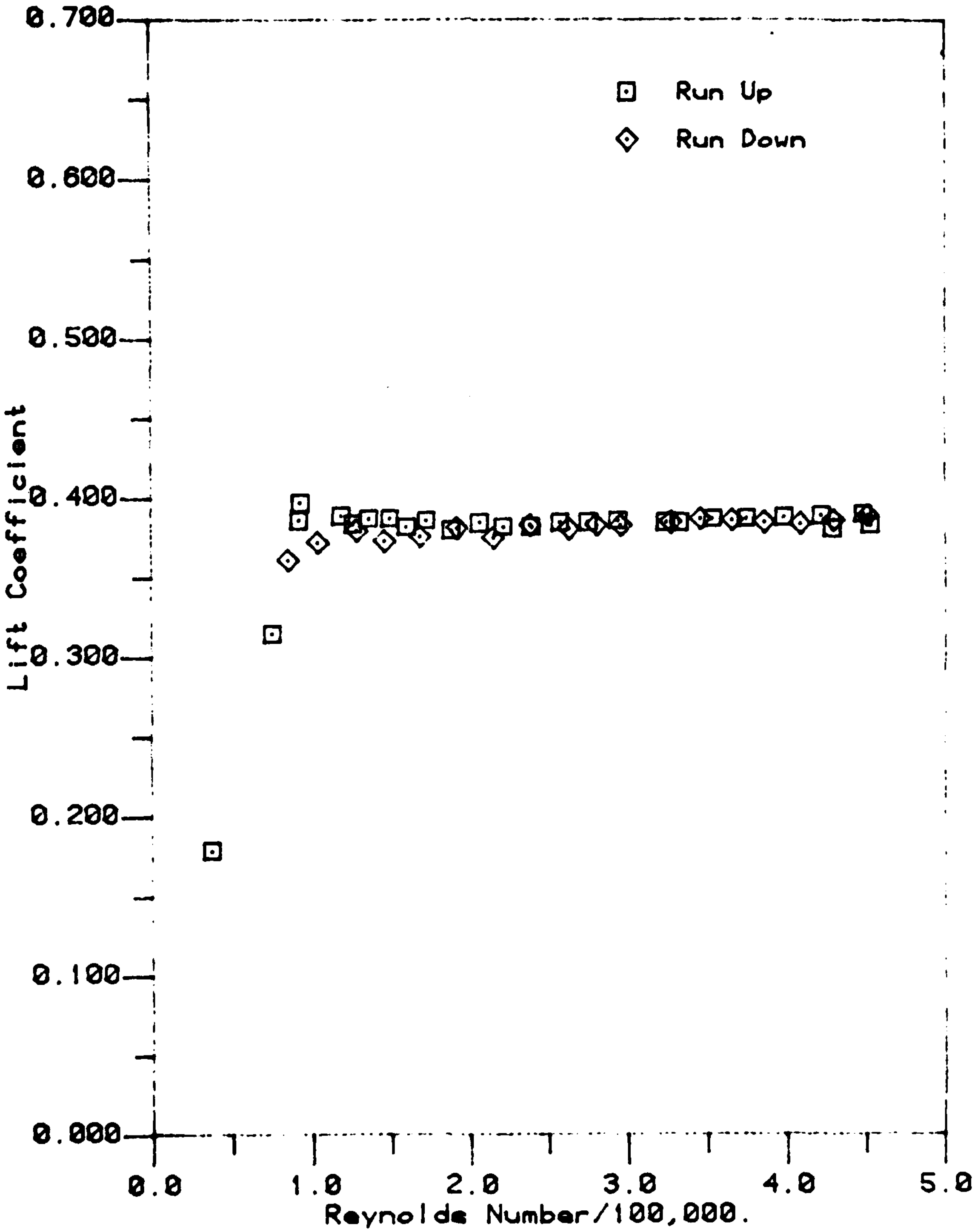
15 Degrees Yaw & Square Tipped Fin

Figure 9.



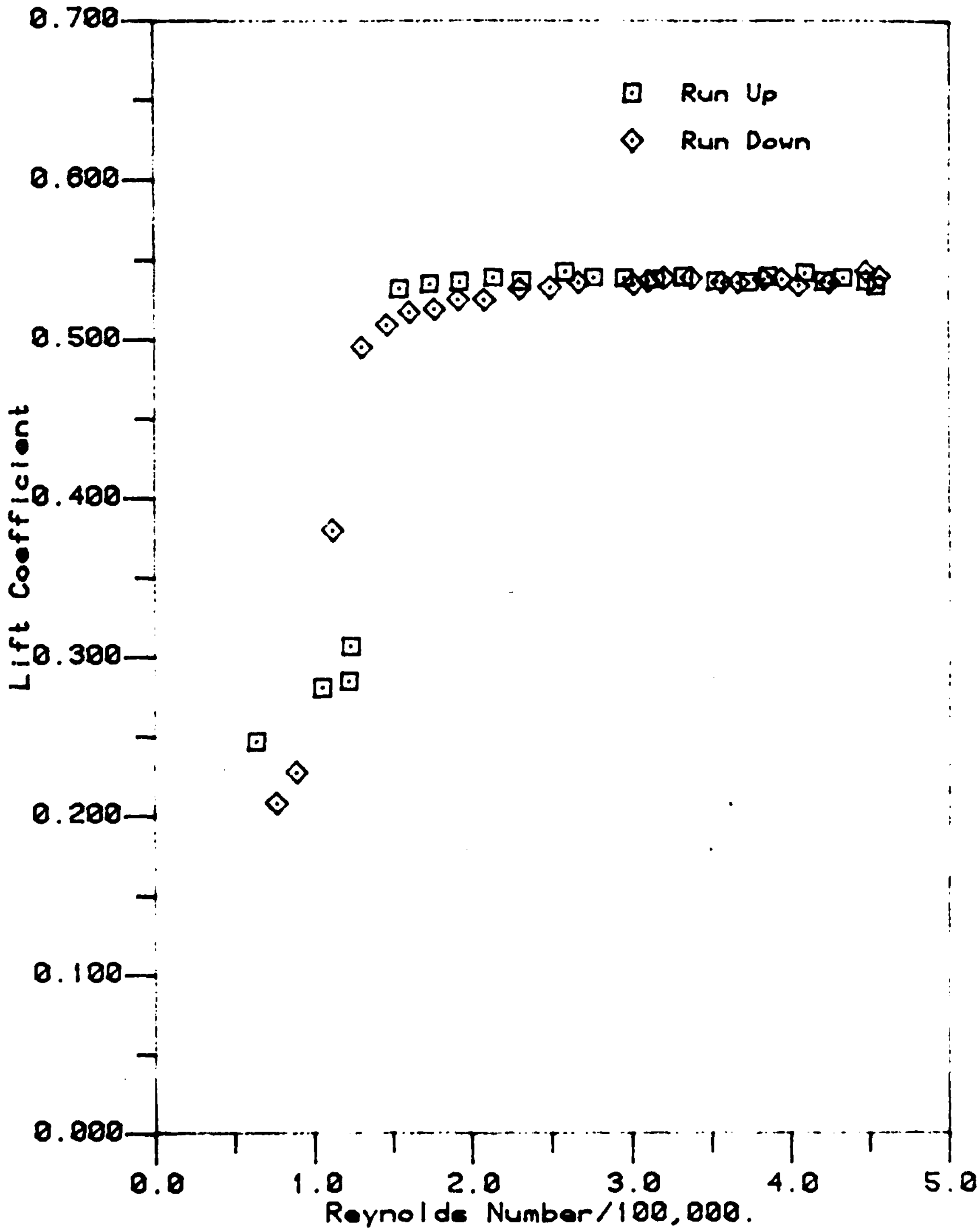
4 Degrees Yaw & Round Tipped Fin

Figure 10.



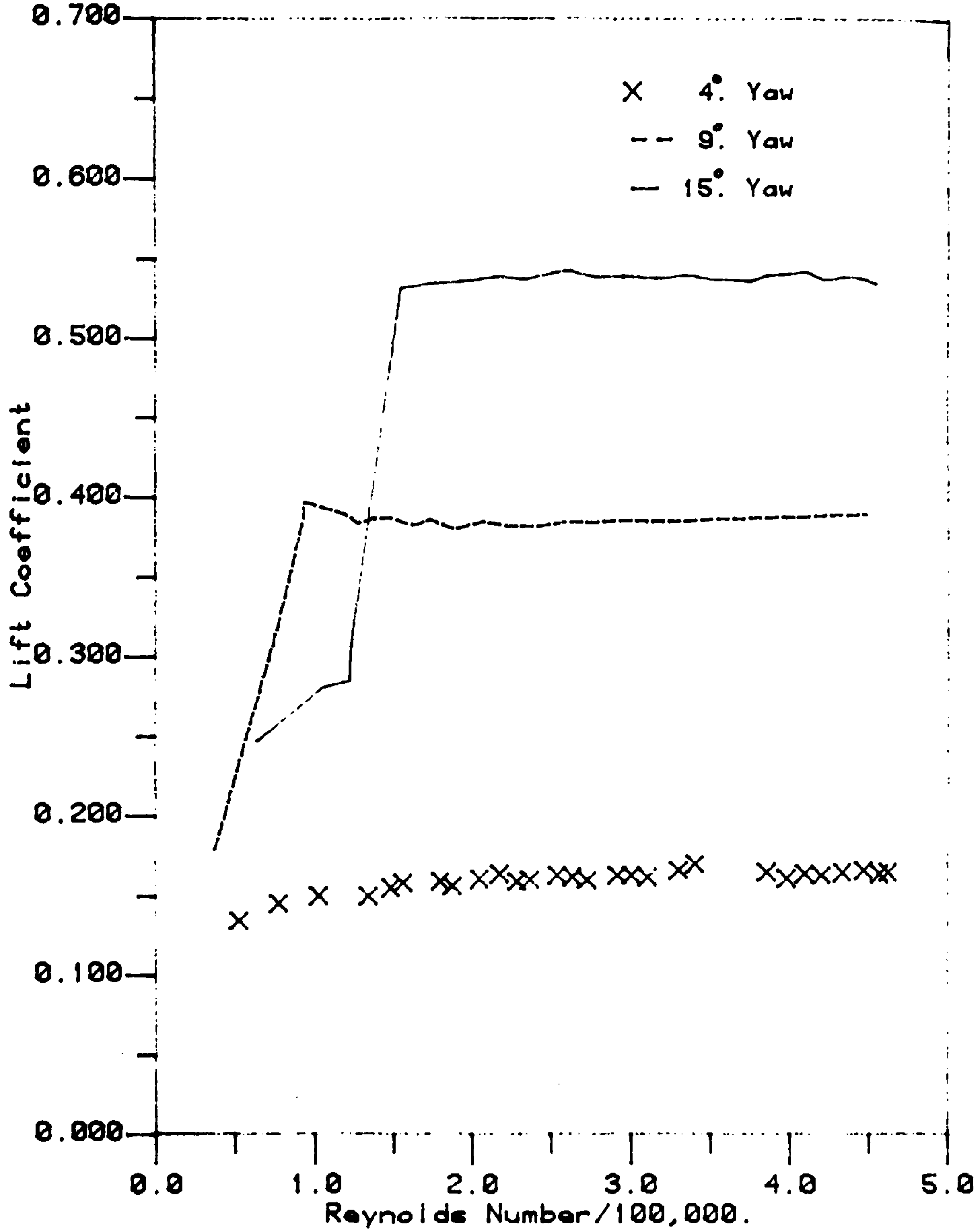
9 Degrees Yaw & Round Tipped Fin

Figure 11.



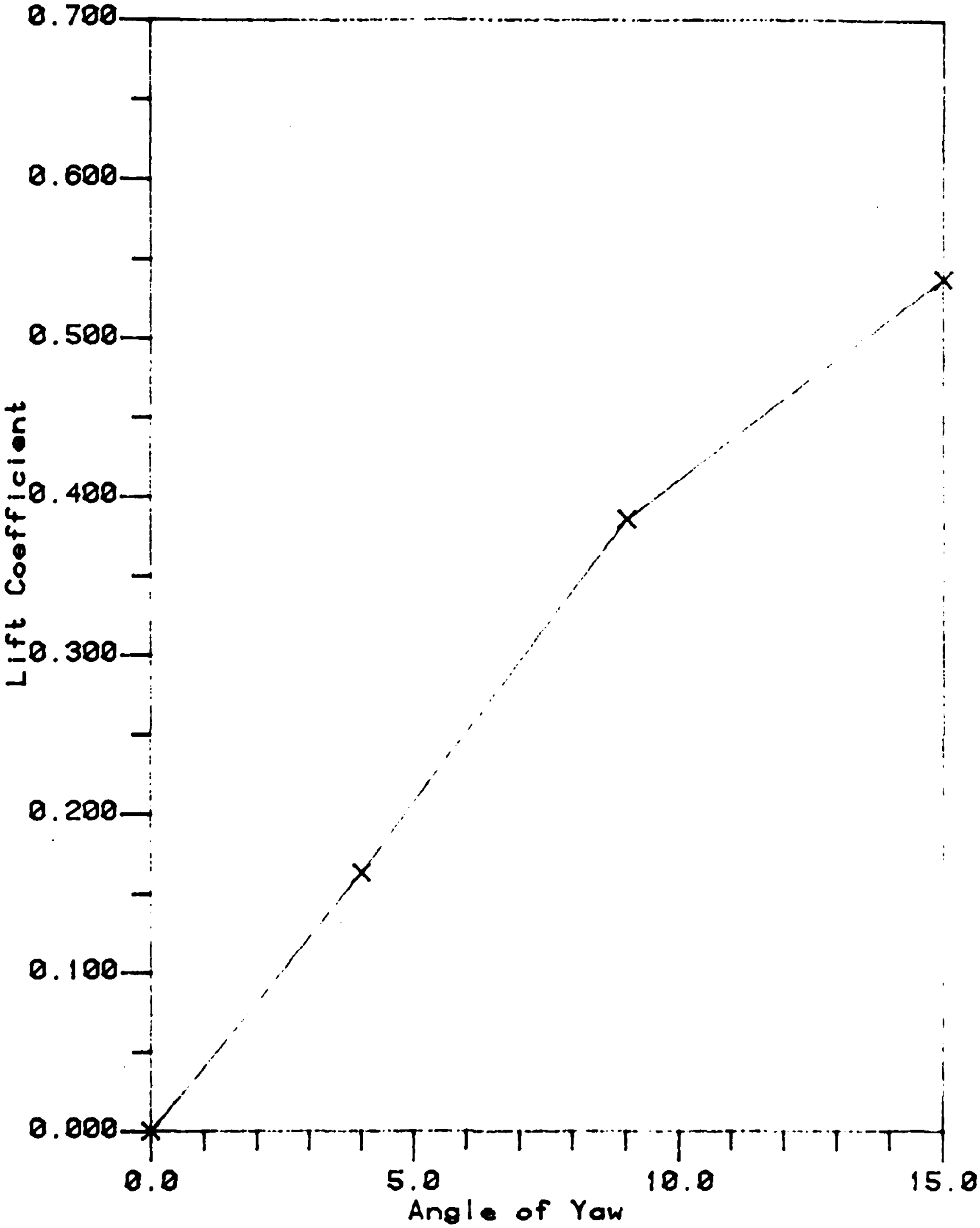
15 Degrees Yaw & Round Tipped Fin

Figure 12.



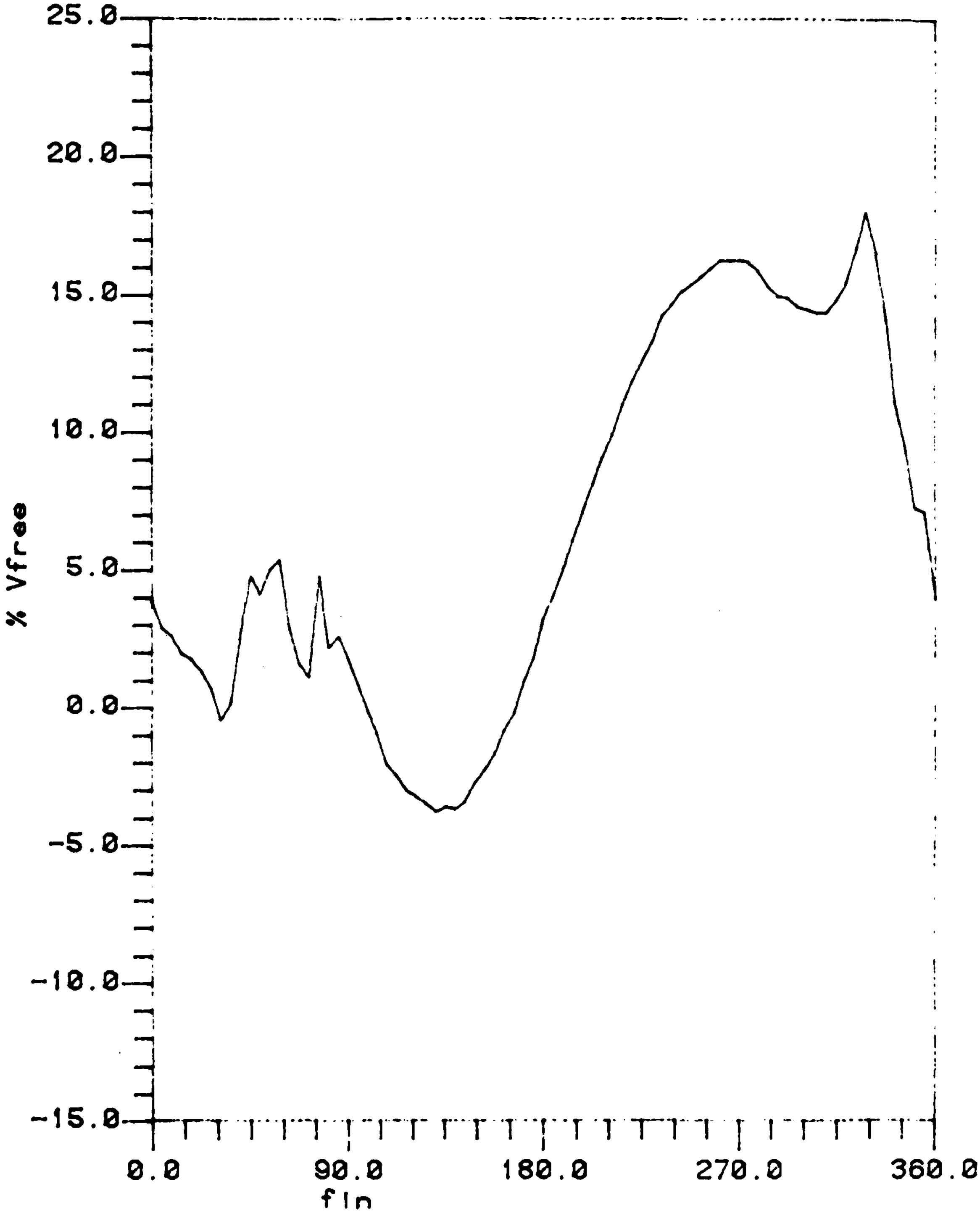
Round Tipped Fin

Figure 13.



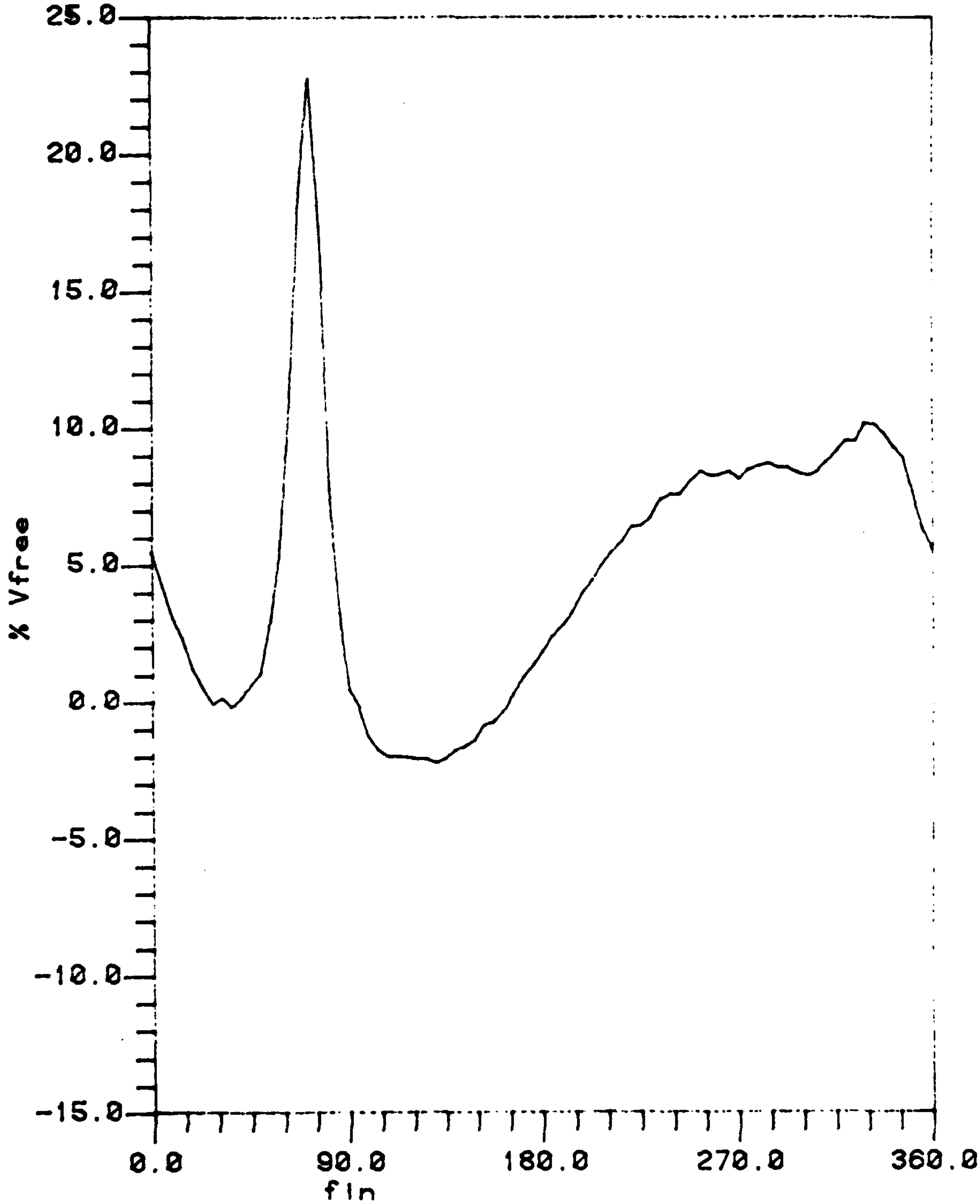
Lift vs Angle of Yaw (Round Tip)

Figure 14.



Tangential Velocity vs Body Rotation
0.35" Stand-off

Figure 15.



Tangential Velocity vs Body Rotation
1.0" Stand-off

Figure 16.

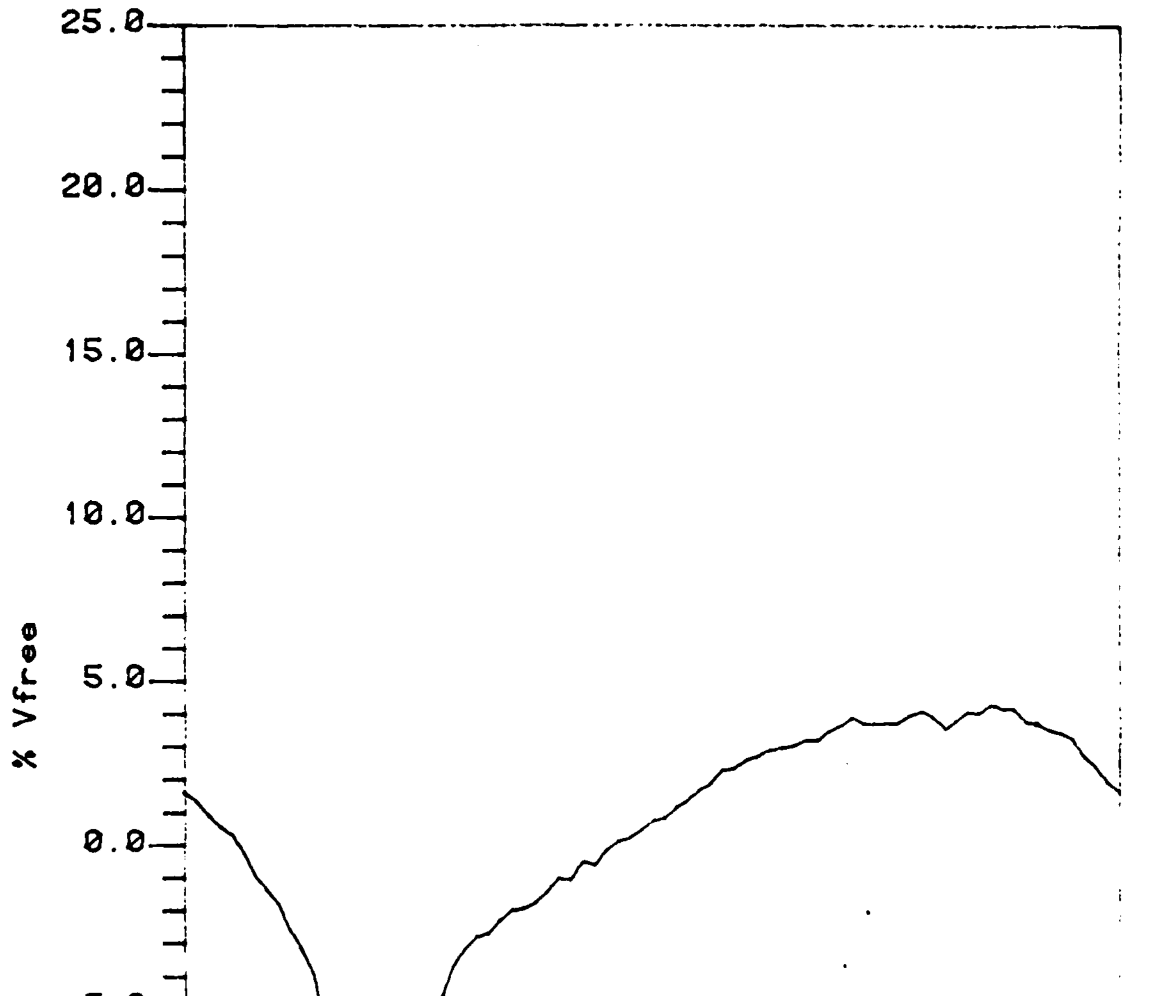
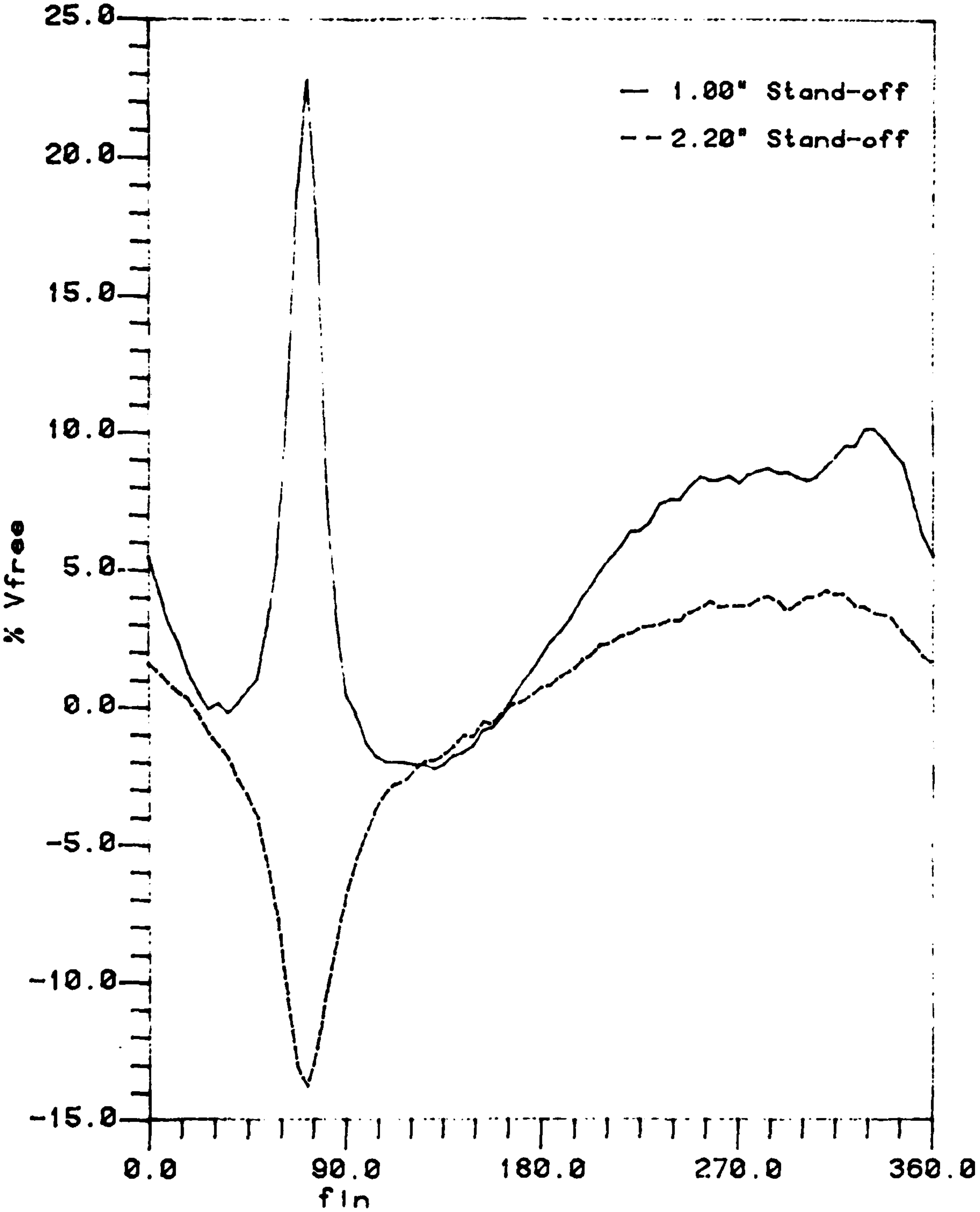
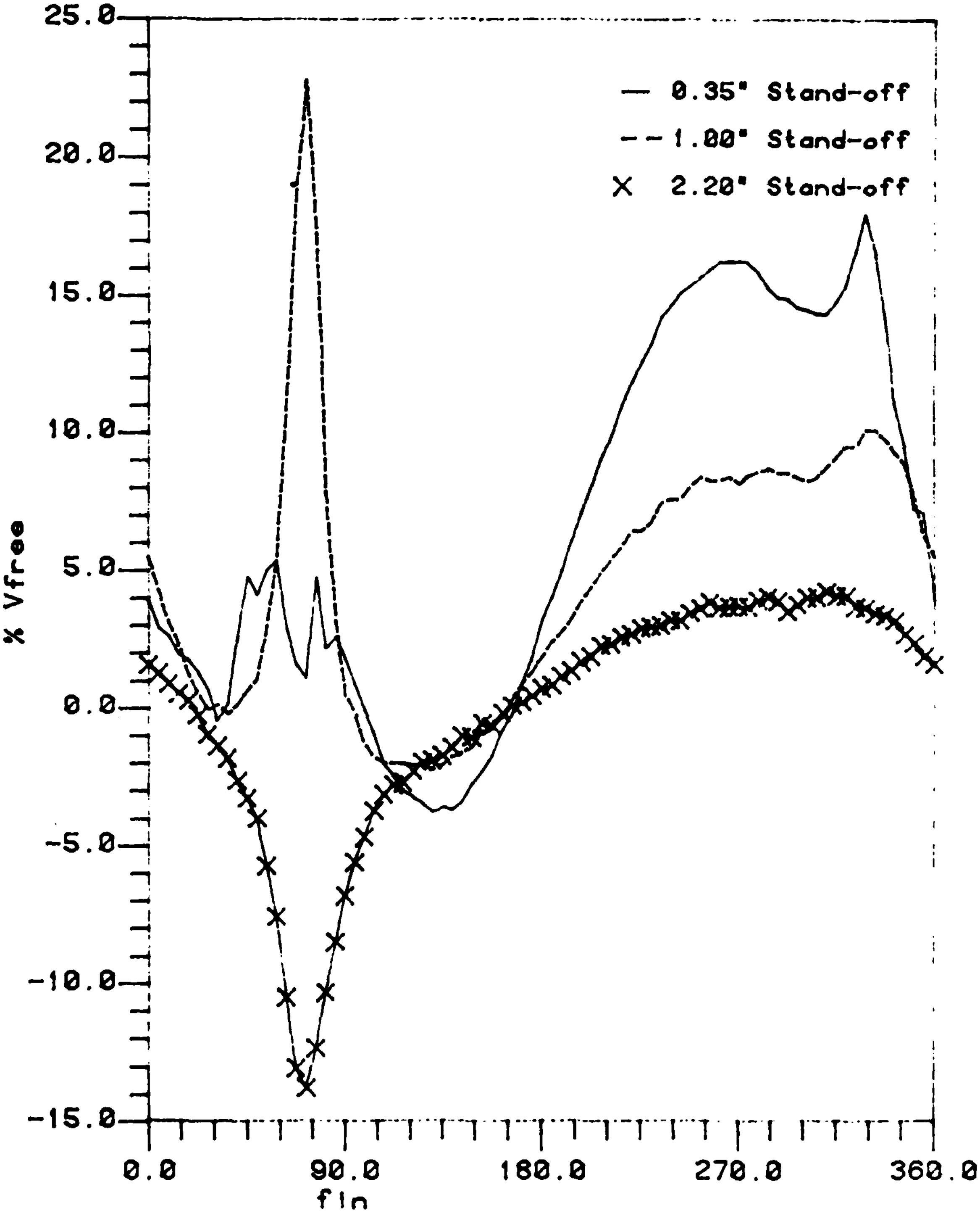

25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
% Vfree
0.0
90.0
180.0
270.0
360.0
fin
Tangential Velocity vs Body Rotation
2.2" Stand-off

Figure 17.



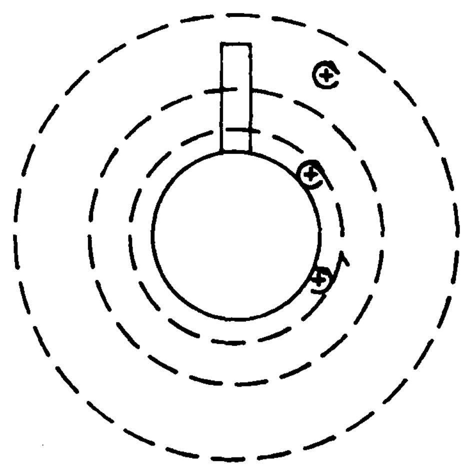
Tangential Velocity vs Body Rotation

Figure 18.



Tangential Velocity vs Body Rotation

Figure 19.



Vortex Locations

Figure 20.

APPENDIX 1

MODEL CHARACTERISTICS

L/D	9.5
LOA	25.602 INCHES
DIAMETER (D)	2.695 INCHES
NOSE LENGTH (L_n)	4.851 INCHES
TAIL LENGTH (L_t)	11.319 INCHES
PARALLEL MIDBODY	9.432 INCHES

NOSE GEOMETRY

$r=D/2*(1-(x/L_n)^2)^0.5$

TAIL GEOMETRY

$r=D/2*(1-0.631*(x/L_t)^2-.369*(x/L_t)^4$

where: r=radius at station x
x=distance from parallel midbody

FIN CHARACTERISTICS

NACA 0022	
ROUND TIPPED SPAN	1.719 INCHES
SQUARE TIPPED SPAN	1.666 INCHES
CHORD	2.053 INCHES
NOSE TO L.E.	6.902 INCHES

where: square and round tipped planform areas are both 3.420 square inches

APPENDIX 2

```
        PROGRAM FMV1
C       FORCE AND MOMENT DEVELOPMENTAL PROGRAM
C
C       TAKES INPUT FROM BALANCE BEAM IN MINC CHANNELS 0 (FORCE)
C       & 1 (MOMENT),LASER HORIZONTAL COMPONENT, AND D/P CELL.
C       AVERAGES VALUES, PRINTS TO SCREEN, AND WRITES TO A FILE.
C       INCLUDES CALIBRATION FACTORS FROM STEVENS INSTITUTE
C
C       SUBROUTINES:MHLLIB,DPCAL,BELL
C
C       START DATE: 06-NOV-86
C
C       RELEASE DATE: 07-JAN-87
C
C
        DIMENSION DAY(3),IDENT(35)
        COMMON /CM4/ZFOR,ZMOM
        COMMON /CM2/VFOR,VMOM,VLASER,VFREE
        COMMON /CM3/RMTMP,TNTMP,VSCTY
        COMMON /CM5/ZERO,FULL
        COMMON /VCONS/RHO,CONLAS
        DOUBLE PRECISION FTITLE
C
C       CREATING OUTPUT FILE
C
        TYPE 100
100     FORMAT (//'  NAME OF OUTPUT FILE? (NO EXT.):',2X,$)
        ACCEPT 101,FTITLE
101     FORMAT (A10)
        TYPE 102
102     FORMAT(////'  ENTER DESCRIPTIVE DATA (<70 CHAR.)'//)
        ACCEPT 103, (IDENT(N),N=1,35)
103     FORMAT (35A2)
        CALL DATE(DAY)
        CALL ASSIGN(2,FTITLE,0,,,)
        WRITE(2,104) FTITLE,(DAY(M),M=1,3)
104     FORMAT (2X,'++DATA FILE:',A10,' ++DATE:',3A4)
        WRITE (2,105) (IDENT(N),N=1,35)
105     FORMAT (1X,35A2)
        WRITE (2,106)
106     FORMAT (T4,'VFREE',T14,'VLASER',T24,'REYNLD',T35,'RFOR',T45,'CFOR'
       ,T55,'RMOM',T65,'CMOM')
        WRITE (2,107)
107     FORMAT (T3,'(FT/SEC)',T13,'(FT/SEC)',T35,'(LB)',T54,'(INLB)')
C
C       INPUTTING CONSTANTS AND CALCULATING PARAMETERS
C
        CALL INPUT
        DATA SFAREA/0.02451/
        DATA CHORD/0.1711/
        DATA SIAREA/3.529/
        DATA CICHOR/2.053/
        RHO=1.9574-0.00028*TNTMP
210     PAUSE 'TYPE RETURN TO SAMPLE ZERO VALUES
C
C       ZEROS READ MINC ZERO VOLTAGES
C
        CALL ZEROS
        TYPE 300,ZFOR,ZMOM
300     FORMAT (/T2,'ZERO VALUES ARE: T24,F . .7,T34,F . .7,
```

```
         TYPE 310
310      FORMAT ('ARE THESE VALUES ACCEPTABLE?(YES=1  NO=0) )
         ACCEPT *,IYORN
320      FORMAT (A2)
         IF (IYORN.EQ.0) GO TO 210
         TYPE 321
321      FORMAT (//' THERE SHOULD BE NO FLUID SPEED FOR DP CELL CAL.'/)
         PAUSE 'TYPE RETURN TO SAMPLE DP CELL'
C
         CALL DPCAL
C
C        BEAM CROSSING ANGLE AND REFRACTIVE CORRECTION
         XKAPA=.0857
         SNELL=1.3298
         XLAMBDA=.488
         VMULT=2.0
         CONLAS=(3.28084/VMULT)*(XLAMBDA/(2.0*SIN(XKAPA)))
322      TYPE 323
323      FORMAT (//,'  DO YOU WANT TO EXIT(0) OR SAMPLE (1)?'/)
         ACCEPT *,IGO
         IF (IGO.EQ.0) GO TO 425
325      PAUSE 'TYPE A CARRIAGE RETURN TO START SAMPLING'
         TYPE 330
330      FORMAT (//'  SAMPLING...'//)
C
C        MEASURE READS BALANCE & VELOCITY VOLTAGES AND AVEREAGES
C
         CALL MEASURE
         RFOR=0.
         RMOM=0.
         RFOR=(VFOR-ZFOR)*4.7415422
         RMOM=(VMOM-ZMOM)*4.73785
         TYPE 400,RFOR,RMOM
400      FORMAT(/T2,'FORCE=',T10,F6.2,T25,'MOMENT=',T34,F6.2)
C
C        CALCULATE COEFFICIENTS
C
         CCOEF=.5*RHO*SFAREA*VFREE*VFREE
C        ----- CRASH PROOFING -------
         IF (CCOEF.LE.0) GO TO 401
         GO TO 404
401      TYPE 402
402      FORMAT(//' ATTEMPT TO DIVIDE BY 0. MORE VEL. )
403      GO TO 325
404      REYNLD=VFREE*CHORD/VSCTY
         CLIFT=RFOR/CCOEF
         CMOM=RMOM/(CCOEF*CHORD)
         TYPE 106
         TYPE 406, VFREE,VLASER,REYNLD,RFOR,CLIFT,RMOM,CMOM
         TYPE 405
405      FORMAT (//'  RECORD DATA? (YES=1 NO=0)')
         ACCEPT *,IR
         IF (IR.EQ.0) GO TO 409
         WRITE(2,406)VFREE,VLASER,REYNLD,RFOR,CLIFT,RMOM,[illegible]
406      FORMAT [illegible] F9.1,T2[illegible]
        T53,F9.3)
409      TYPE 410
410      FORMAT [illegible] WOULD YOU LIKE ANOTHER POINT? (YES 1 [illegible]
         ACCEPT *,I[illegible]N
420      FORMAT (A2)
```

```
      IF (IYON.EQ.1) GO TO 325
425   TYPE 426
426   FORMAT (//'  ARE YOU SURE YOU WANT TO QUIT?(YES=0 NO=1)'/)
      ACCEPT *,ION
      IF (ION.EQ.1) GO TO 325
      STOP=999.99
      WRITE (2,406) STOP,STOP,STOP,STOP,STOP,STOP,STOP
      WRITE (2,406) STOP,STOP,STOP,STOP,STOP,STOP,STOP
      TYPE 501,FTITLE
501   FORMAT (///'  DATA FILE:',A10,' GENERATED SUCCESSFULLY')
      END
C
      SUBROUTINE ZEROS
      COMMON/CM4/ZFOR,ZMOM
      DIMENSION IDVAL(401),DVAL(401)
      ZFOR=0.0
      ZMOM=0.0
      CALL ADFAST(0,1,200.,1,IDVAL,DVAL,200,IER)
      IF (IER.EQ.1) GO TO 200
      IND=0
      DO 10 I=1,399,2
       ZFOR=ZFOR+DVAL(I)
       ZMOM=ZMOM+DVAL(I+1)
       IND=IND+1
10    CONTINUE
      ZFOR=ZFOR/200.
      ZMOM=ZMOM/200.
      GO TO 250
200   TYPE 210
210   FORMAT(//'MINC CAN NOT KEEP UP W/ADFAST')
250   RETURN
      END
C
      SUBROUTINE INPUT
      COMMON/CM3/RMTMP,TNTMP,VSCTY
      TYPE 2
2     FORMAT(/'INPUT ROOM TEMP (F)'/)
      ACCEPT *,RMTMP
      TYPE 4
4     FORMAT(/'INPUT TUNNEL TEMP (F)'/)
      ACCEPT *,TNTMP
      TYPE 6
6     FORMAT (/'INPUT VISCOCITY (FT^2/SEC)'/)
      ACCEPT *,VSCTY
      RETURN
      END
C
      SUBROUTINE MEASURE
      COMMON /CM5/ZERO,FULL
      COMMON /VCONS/RHO,CONLAS
      COMMON/CM2/VFOR,VMOM,VLASER,VFREE
      DIMENSION IDVAL(2401),DVAL(2401)
      VFOR=0.0
      VMOM=0.0
      DFVLT=0.0
      VTLAS=0.0
      CALL ADFAST(0,11,400.,1,IDVAL,DVAL,[illegible]
      IF (IER.EQ.1) GO TO 200
      DO 10 I=1,2389,12
       VFOR=VFOR+DVAL(I)
```

```
      VMOM=VMOM+DVAL(I+1)
      DPVLT=DPVLT+DVAL(I+10)
      VTLAS=VTLAS+DVAL(I+11)
10    CONTINUE
      VTLAS=VTLAS/200.+2.
      DPVLT=DPVLT/200.
      DPRAT=(DPVLT-ZERO)/(FULL-ZERO)
      VFREE=45.2589/RHO*DPRAT**.4985
      VLASER=VTLAS*CONLAS
      VFOR=VFOR/200.
      VMOM=VMOM/200.
      GO TO 215
200   TYPE 210
210   FORMAT(//'MINC CAN NOT KEEP UP WITH ADFAST')
215   RETURN
      END
```

APPENDIX 3

```
      PROGRAM CIRC2
C
C     PROGRAM USES BODROT TO DETERMINE POINTS ON A CIRCULAR
C     CICULATION PATH AROUND BODY W/ FIN
C     LASSUB GETS VERTICAL VELOCITY FROM LASER AND CHANNEL D
C
C
C     SUBROUTINES:MHLLIB,DPCAL,BELL,BDRT,LASSUB,INVM
C
C     AUTHOR: JEFF REED
C
C     RELEASED:2/4/87
C
      DIMENSION DAY(3),IDENT(35),TVLAS(128)
      COMMON IDVAL(1025),DVAL(1025),ZERO,FULL
      COMMON /VCONS/RHO,CONLAS
      DOUBLE PRECISION FTITLE
      TYPE 900
900   FORMAT(/' ***CIRCULAR PATH LASER VELOCITY PROGRAM***'//
     ^' ENTER NAME OF OUTPUT FILE',2X,$)
      ACCEPT 901,FTITLE
901   FORMAT (A10)
      TYPE 902
902   FORMAT (///'INPUT ID HEADER (up to 70 characters)')
      ACCEPT 903, (IDENT(N),N=1,35)
903   FORMAT (35A2)
      CALL DATE(DAY)
      CALL ASSIGN(2,FTITLE,0,,,)
      WRITE (2,904) FTITLE,(DAY(M),M=1,3)
904   FORMAT (2X,'DATA FILE:',A10,' DATE:',3A4)
      WRITE (2,905) (IDENT(N),N=1,35)
905   FORMAT (1X,35A2)
      TYPE 906
906   FORMAT (///' INPUT WATER TEMPERATURE:',2X,$)
      ACCEPT *,TTUN
      RHO=1.9574-0.00028*TTUN
      CALL DPCAL
      XKAPA=0.0857
      SNELL=1.3298
      VMULT=2.0
      LAMDA=0.5145
      CONLAS=4.92681
      TYPE 800
      ACCEPT *,QA
      TYPE 801
      ACCEPT *,XMI
      XM=XMI-12.92
      TYPE 802
      ACCEPT *,DEG
      TYPE 803
      ACCEPT *,RM
800   FORMAT ('  INPUT YAW ANGLE OF MODEL (DEG):',2X,$)
801   FORMAT ('  INPUT XM OF MODEL (FROM BOW):',2X,$)
802   FORMAT ('  INPUT DEGREE INCREMENTS IN WHICH MODEL WILL BE
     ^ ROTATED:',2X,$)
803   FORMAT ('  INPUT RADIUS AT WHICH MEASUREMENTS WILL BE MADE
     ^:',2X,$)
      IN=360./DEG
      WRITE (2,804) QA,XMI
804   FORMAT (' YAW ANGLE=',F4.1,,3X,'XM FROM BOW=',F5.2)
```

```
      WRITE (2,805)
805   FORMAT (//3X,'XM',10X,'YM',7X,'ZM','   ROTATION  VLASER
     -  VFREE    RATIO    PERCENT')
      DO 500 JR=0,IN
              RA=JR*DEG
              CALL BDRT(XM,YM,ZM,XL,YL,ZL,QA,RA,RM)
450           CALL LASSUB(VLASER,VFREE)
              VRATIO=VLASER/VFREE
              TYPE 700,VLASER,VFREE,VRATIO
700           FORMAT (' VERTICAL VELOCITY=',F7.3,2X,'VFREE=',
     -F7.3,2X,'VRATIO=',F7.4)
              TYPE 701
701           FORMAT (' RECORD THIS DATA?(N=0,Y=1) ',$)
              ACCEPT *,IRCD
              IF (IRCD.EQ.0) GO TO 450
              WRITE (2,702) XMI,YM,ZM,RA,VLASER,VFREE,VRATIO
702           FORMAT (3(F8.4,2X),F6.1,2X,2(F7.3,2X),F8.4)
              TYPE *,'TYPE 7 IF YOU WANT TO QUIT, 0 TO CONTINUE'
              ACCEPT *,IQ
              IF (IQ.EQ.7) GO TO 501
              PAUSE ' TYPE RETURN TO GENERATE & SAMPLE NEXT POINT'
500   CONTINUE
501   STOP
      END
```

APPENDIX 4

```
        PROGRAM HFINF
C
C       DETERMINES POINTS ON A POSITIVE HORIZONTAL
C       CIRCULATION LEG AROUND FIN
C       LASSUB GETS VERTICAL VELOCITY FROM LASER AND CHANNEL D
C
C
C       SUBROUTINES:MHLLIB,DPCAL,BELL,LASSUB
C
C       AUTHOR: JEFF REED
C
C       RELEASED:
C
        DIMENSION DAY(3),IDENT(35),TVLAS(128)
        COMMON IDVAL(1025),DVAL(1025),ZERO,FULL
        COMMON /VCONS/RHO,CONLAS
        DOUBLE PRECISION FTITLE
        TYPE 900
900     FORMAT(/' ***FIN CONTOUR LASER VELOCITY PROGRAM***'//
     ^' ENTER NAME OF OUTPUT FILE',2X,$)
        ACCEPT 901,FTITLE
901     FORMAT (A10)
        TYPE 902
902     FORMAT (///'INPUT ID HEADER (up to 70 characters)')
        ACCEPT 903, (IDENT(N),N=1,35)
903     FORMAT (35A2)
        CALL DATE(DAY)
        CALL ASSIGN(2,FTITLE,0,,,)
        WRITE (2,904) FTITLE,(DAY(M),M=1,3)
904     FORMAT (2X,'DATA FILE:',A10,' DATE:',3A4)
        WRITE (2,905) (IDENT(N),N=1,35)
905     FORMAT (1X,35A2)
        TYPE 906
906     FORMAT (///' INPUT WATER TEMPERATURE:',2X,$)
        ACCEPT *,TTUN
        RHO=1.9574-0.00028*TTUN
        CALL DPCAL
        CONLAS=4.676229
        WRITE (2,805)
805     FORMAT (//3X,'XS',10X,'YS',7X,'ZS','        VLASER
     ^    VFREE    RATIO')
        TYPE*,'ZERO LASER ON LEADING EDGE OF SAIL'
        TYPE*,'INPUT DISTANCE TOWARD ROOT FROM TIP WHERE CONTOUR'
        TYPE *,' WILL BE MADE IN INCHES (SPAN=1.719")'
        ACCEPT *,ZS
        ZSL=ZS*-25.4
        YS=.65
        YSL=YS*25.4
        DO 500 JR=0,24
                XS=JR*.1-.2
                XSL=XS*25.4
                TYPE 400,XS,YS,ZS
400             FORMAT (' XS=',F6.2,2X,'YS=',F6.2,2X,'ZS=',F6.2)
                XL=-1*ZSL/1.3298
                YL=-1*XSL
                ZL=YSL
                TYPE 401,XL,YL,ZL
401             FORMAT (' XL=',F6.2,2X,'YL=',F6.2,2X,'ZL=',F6.2)
450             CALL LASSUB(VLASER,VFREE)
                VRATIO=VLASER/VFREE
```

```
            TYPE 700,VLASER,VFREE,VRATIO
700         FORMAT (' VERTICAL VELOCITY=',F7.3,2X,'VFREE=',
     ^F7.3,2X,'VRATIO=',F7.4)
            TYPE 701
701         FORMAT (' RECORD THIS DATA?(N=0,Y=1) ',$)
            ACCEPT *,IRCD
            IF (IRCD.EQ.0) GO TO 450
            WRITE (2,702) XS,YS,ZS,VLASER,VFREE,VRATIO
702         FORMAT (3(F8.4,2X),2X,2(F7.3,2X),F8.4)
            TYPE *,'TYPE 7 IF YOU WANT TO QUIT, 0 TO CONTINUE'
            ACCEPT *,IQ
            IF (IQ.EQ.7) GO TO 501
            PAUSE ' TYPE RETURN TO GENERATE & SAMPLE NEXT POINT'
500   CONTINUE
501   STOP
      END
```

```
      PROGRAM HFINM
C
C     DETERMINES POINTS ON A NEGATIVE HORIZONTAL
C     CIRCULATION LEG AROUND FIN
C     LASSUB GETS VERTICAL VELOCITY FROM LASER AND CHANNEL D
C
C
C     SUBROUTINES:MHLLIB,DPCAL,BELL,LASSUB
C
C     AUTHOR: JEFF REED
C
C     RELEASED:
C
      DIMENSION DAY(3),IDENT(35),TVLAS(128)
      COMMON IDVAL(1025),DVAL(1025),ZERO,FULL
      COMMON /VCONS/RHO,CONLAS
      DOUBLE PRECISION FTITLE
      TYPE 900
900   FORMAT(/' ***FIN CONTOUR LASER VELOCITY PROGRAM***'//
     -' ENTER NAME OF OUTPUT FILE',2X,$)
      ACCEPT 901,FTITLE
901   FORMAT (A10)
      TYPE 902
902   FORMAT (//'INPUT ID HEADER (up to 70 characters)')
      ACCEPT 903, (IDENT(N),N=1,35)
903   FORMAT (35A2)
      CALL DATE(DAY)
      CALL ASSIGN(2,FTITLE,0,,,)
      WRITE (2,904) FTITLE,(DAY(M),M=1,3)
904   FORMAT (2X,'DATA FILE:',A10,' DATE:',3A4)
      WRITE (2,905) (IDENT(N),N=1,35)
905   FORMAT (1X,35A2)
      TYPE 906
906   FORMAT (//' INPUT WATER TEMPERATURE:',2X,$)
      ACCEPT *,TTUN
      RHO=1.9574-0.00028*TTUN
      CALL DPCAL
      CONLAS=4.676229
      WRITE (2,805)
805   FORMAT (//3X,'XS',10X,'YS',7X,'ZS',' VLASER
     -  VFREE    RATIO')
      TYPE*,'ZERO LASER ON LEADING EDGE OF SAIL'
      TYPE*,'INPUT DISTANCE TOWARD ROOT FROM TIP WHERE CONTOUR'
      TYPE *,' WILL BE MADE IN INCHES (SPAN=1.719")'
      ACCEPT *,ZS
      ZSL=ZS*-25.4
      YS=-.45
      YSL=YS*25.4
      DO 500 JR=0,24
            XS=2.2-.1*JR
            XSL=XS*25.4
            TYPE 400,XS,YS,ZS
400         FORMAT (' XS=',F6.2,2X,'YS=',F6.2,2X,'ZS=',F6.2)
            XL=-1*ZSL/1.3298
            YL=-1*XSL
            ZL=YSL
            TYPE 401,XL,YL,ZL
401         FORMAT (' XL=',F6.2,2X,'YL=',F6.2,2X,'ZL=',F6.2)
450         CALL LASSUB(VLASER,VFREE)
            VRATIO=VLASER/VFREE
```

```
          TYPE 700,VLASER,VFREE,VRATIO
700       FORMAT (' VERTICAL VELOCITY=',F7.3,2X,'VFREE=',
     ^F7.3,2X,'VRATIO=',F7.4)
          TYPE 701
701       FORMAT (' RECORD THIS DATA?(N=0,Y=1) ',$)
          ACCEPT *,IRCD
          IF (IRCD.EQ.0) GO TO 450
          WRITE (2,702) XS,YS,ZS,VLASER,VFREE,VRATIO
702       FORMAT (3(F8.4,2X),2X,2(F7.3,2X),F8.4)
          TYPE *,'TYPE 7 IF YOU WANT TO QUIT, 0 TO CONTINUE'
          ACCEPT *,IQ
          IF (IQ.EQ.7) GO TO 501
          PAUSE ' TYPE RETURN TO GENERATE & SAMPLE NEXT POINT'
500    CONTINUE
501    STOP
       END
```

```
      PROGRAM VFINP
C
C     DETERMINES POINTS ON A POSITIVE HORIZONTAL
C     CIRCULATION LEG AROUND FIN
C     LASSUB GETS VERTICAL VELOCITY FROM LASER AND CHANNEL D
C
C
C     SUBROUTINES:MHLLIB,DPCAL,BELL,LASSUB
C
C     AUTHOR: JEFF REED
C
C     RELEASED:
C
      DIMENSION DAY(3),IDENT(35),TVLAS(128)
      COMMON IDVAL(1025),DVAL(1025),ZERO,FULL
      COMMON /VCONS/RHO,CONLAS
      DOUBLE PRECISION FTITLE
      TYPE 900
900   FORMAT(/' ***FIN CONTOUR LASER VELOCITY PROGRAM***'//
     -' ENTER NAME OF OUTPUT FILE',2X,$)
      ACCEPT 901,FTITLE
901   FORMAT (A10)
      TYPE 902
902   FORMAT (//'INPUT ID HEADER (up to 70 characters)')
      ACCEPT 903, (IDENT(N),N=1,35)
903   FORMAT (35A2)
      CALL DATE(DAY)
      CALL ASSIGN(2,FTITLE,0,,,)
      WRITE (2,904) FTITLE,(DAY(M),M=1,3)
904   FORMAT (2X,'DATA FILE:',A10,' DATE:',3A4)
      WRITE (2,905) (IDENT(N),N=1,35)
905   FORMAT (1X,35A2)
      TYPE 906
906   FORMAT (//' INPUT WATER TEMPERATURE:',2X,$)
      ACCEPT *,TTUN
      RHO=1.9574-0.00028*TTUN
      CALL DPCAL
      CONLAS=4.92681
      WRITE (2,805)
805   FORMAT (//3X,'XS',10X,'YS',7X,'ZS','         VLASER
     -  VFREE    RATIO')
      TYPE*,'ZERO LASER ON LEADING EDGE OF SAIL'
      TYPE*,'INPUT DISTANCE TOWARD ROOT FROM TIP WHERE CONTOUR'
      TYPE *,' WILL BE MADE IN INCHES (SPAN 1.719")'
      ACCEPT *,ZS
      ZSL=ZS*-25.4
      XS=-.2
      XSL=XS*25.4
      DO 500 JR=0,11
            YS=JR*.1-.45
            YSL=YS*25.4
            TYPE 400,XS,YS,ZS
400         FORMAT (' XS=',F6.2,2X,'YS=',F6.2,2X,'ZS=',F6.2)
            XL=-1*ZSL/1.3298
            YL=-1*XSL
            ZL=YSL
            TYPE 401,XL,YL,ZL
401         FORMAT (' XL=',F6.2,2X,'YL=',F6.2,2X,'ZL=',F6.2)
450         CALL LASSUB(VLASER,VFREE)
            VRATIO=VLASER/VFREE
```

```
              TYPE 700,VLASER,VFREE,VRATIO
700           FORMAT (' VERTICAL VELOCITY=',F7.3,2X,'VFREE=',
     *F7.3,2X,'VRATIO=',F7.4)
              TYPE 701
701           FORMAT (' RECORD THIS DATA?(N=0,Y=1) ',$)
              ACCEPT *,IRCD
              IF (IRCD.EQ.0) GO TO 450
              WRITE (2,702) XS,YS,ZS,VLASER,VFREE,VRATIO
702           FORMAT (3(F8.4,2X),2X,2(F7.3,2X),F8.4)
              TYPE *,'TYPE 7 IF YOU WANT TO QUIT, 0 TO CONTINUE'
              ACCEPT *,IQ
              IF (IQ.EQ.7) GO TO 501
              PAUSE ' TYPE RETURN TO GENERATE & SAMPLE NEXT POINT'
500     CONTINUE
501     STOP
        END
```

```
      PROGRAM VFINM
C
C     DETERMINES POINTS ON A POSITIVE HORIZONTAL
C     CIRCULATION LEG AROUND FIN
C     LASSUB GETS VERTICAL VELOCITY FROM LASER AND CHANNEL D
C
C
C     SUBROUTINES:MHLLIB,DPCAL,BELL,LASSUB
C
C     AUTHOR: JEFF REED
C
C     RELEASED:
C
      DIMENSION DAY(3),IDENT(35),TVLAS(128)
      COMMON IDVAL(1025),DVAL(1025),ZERO,FULL
      COMMON /VCONS/RHO,CONLAS
      DOUBLE PRECISION FTITLE
      TYPE 900
900   FORMAT(/' ***FIN CONTOUR LASER VELOCITY PROGRAM***'//
     ~' ENTER NAME OF OUTPUT FILE',2X,$)
      ACCEPT 901,FTITLE
901   FORMAT (A10)
      TYPE 902
902   FORMAT (//'INPUT ID HEADER (up to 70 characters)')
      ACCEPT 903, (IDENT(N),N=1,35)
903   FORMAT (35A2)
      CALL DATE(DAY)
      CALL ASSIGN(2,FTITLE,0,,,)
      WRITE (2,904) FTITLE,(DAY(M),M=1,3)
904   FORMAT (2X,'DATA FILE:',A10,' DATE:',3A4)
      WRITE (2,905) (IDENT(N),N=1,35)
905   FORMAT (1X,35A2)
      TYPE 906
906   FORMAT (//' INPUT WATER TEMPERATURE:',2X,$)
      ACCEPT *,TTUN
      RHO=1.9574-0.00028*TTUN
      CALL DPCAL
      CONLAS=4.92681
      WRITE (2,805)
805   FORMAT (//3X,'XS',10X,'YS',7X,'ZS','        VLASER
     ~  VFREE    RATIO')
      TYPE*,'ZERO LASER ON LEADING EDGE OF SAIL'
      TYPE*,'INPUT DISTANCE TOWARD ROOT FROM TIP WHERE CONTOUR'
      TYPE *,' WILL BE MADE IN INCHES (SPAN=1.719")'
      ACCEPT *,ZS
      ZSL=ZS*-25.4
      XS=2.2
      XSL=XS*25.4
      DO 500 JR=0,11
             YS=.65-JR*.1
             YSL=YS*25.4
             TYPE 400,XS,YS,ZS
400          FORMAT (' XS=',F6.2,2X, YS=',F6.2,2X,'ZS=',F6.2)
             XL=-1*ZSL/1.3298
             YL=-1*XSL
             ZL=YSL
             TYPE 401,XL,YL,ZL
401          FORMAT (' XL=',F6.2,2X,'YL=',F6.2,2X,'ZL= ,F6.2)
450          CALL LASSUB(VLASER,VFREE)
             VRATIO VLASER/VFREE
```

```
                TYPE 700,VLASER,VFREE,VRATIO
700             FORMAT (' VERTICAL VELOCITY=',F7.3,2X,'VFREE=',
     ^F7.3,2X,'VRATIO=',F7.4)
                TYPE 701
701             FORMAT (' RECORD THIS DATA?(N=0,Y=1) ',$)
                ACCEPT *,IRCD
                IF (IRCD.EQ.0) GO TO 450
                WRITE (2,702) XS,YS,ZS,VLASER,VFREE,VRATIO
702             FORMAT (3(F8.4,2X),2X,2(F7.3,2X),F8.4)
                TYPE *,'TYPE 7 IF YOU WANT TO QUIT, 0 TO CONTINUE'
                ACCEPT *,IQ
                IF (IQ.EQ.7) GO TO 501
                PAUSE ' TYPE RETURN TO GENERATE & SAMPLE NEXT POINT'
500       CONTINUE
501       STOP
          END
```

APPENDIX 5

```
      PROGRAM LFTGRA
C     Graphs Z coordinate and Velocity Ratio from LASVEL
C     Reads everything so chenges would be simple
      DIMENSION VFREE(200),VLASER(200),REYNLD(200),RFOR(200),
     1          CLIFT(200),RMOM(200),CMOM(200)
      DOUBLE PRECISION FTITLE
1     TYPE 100
100   FORMAT(//' INPUT NAME OF FILE TO BE PLOTTED',2X,$)
      ACCEPT 110,FTITLE
110   FORMAT(A10)
      CALL ASSIGN(2,FTITLE,0,OLD,,)
      READ(2,160)
160   FORMAT(////)
      DO 2, I=1,200
      READ(2,*) VFREE(I),VLASER(I),REYNLD(I),
     1          RFOR(I),CLIFT(I),RMOM(I),CMOM(I)
120   FORMAT(T3,F5.2,T13,F5.2,T22,F9.1,T34,F5.2,T42,F9.3,T54,F5.2,
     1       T62,F9.3)
      NP=I-1
      REYNLD(I)=REYNLD(I)/100000.0
      CLIFT(I)=CLIFT(I)*-1.0
      TYPE *, VFREE(I),REYNLD(I),CLIFT(I)
      IF(VFREE(I).EQ.999.99) GO TO 3
2     CONTINUE
3     TYPE 130
      TYPE *,NP
130   FORMAT(//' PLOT ON TOP OF PREVIOUS GRAPH? Y=1,N=0',$)
      ACCEPT *,INEW
      IF(INEW.EQ.1) GO TO 4
      NEW=0
4     NEW=NEW+1
      TYPE 140
140   FORMAT(//' MODE=?',$)
      ACCEPT *,MODE
      CALL GRAPHA(REYNLD,CLIFT,NP,NEW,MODE)
      CALL CLOSE(2)
      TYPE 150
150   FORMAT(//' ANOTHER FILE? Y=1,N=0',$)
      ACCEPT *,IGO
      IF(IGO.EQ.0) GO TO 5
      GO TO 1
5     STOP
      END
```

APPENDIX 6

```
      PROGRAM VELCON
C     Graphs Z coordinate and Velocity Ratio from LASVEL
C     Reads everything so changes would be simple
      DIMENSION XMI(200),YM(200),ZM(200),RA(200),
     1          VLASER(200),VFREE(200),VRATIO(200)
      DOUBLE PRECISION FTITLE
1     TYPE 100
100   FORMAT(///' INPUT NAME OF FILE TO BE PLOTTED',2X,$)
      ACCEPT 110,FTITLE
110   FORMAT(A10)
      CALL ASSIGN(2,FTITLE,0,OLD,,)
      READ(2,160)
160   FORMAT(///)
      DO 2, I=1,200
      READ(2,*) XMI(I),YM(I),ZM(I),
     1          RA(I),VLASER(I),VFREE(I),VRATIO(I)
120   FORMAT(3(F8.4,2X),F6.1,2X,2(F7.3,2X),F8.4)
      NP=I-1
      VRATIO(I)=VRATIO(I)*100.
      TYPE *, RA(I),VRATIO(I)
      IF(XMI(I).EQ.999.99) GO TO 3
2     CONTINUE
3     TYPE 130
      TYPE *,NP
130   FORMAT(///' PLOT ON TOP OF PREVIOUS GRAPH? Y=1,N=0',$)
      ACCEPT *,INEW
      IF(INEW.EQ.1) GO TO 4
      NEW=0
4     NEW=NEW+1
      TYPE 140
140   FORMAT(///' MODE=?',$)
      ACCEPT *,MODE
      CALL GRAPHA(RA,VRATIO,NP,NEW,MODE)
      CALL CLOSE(2)
      TYPE 150
150   FORMAT(///' ANOTHER FILE? Y=1,N=0',$)
      ACCEPT *,IGO
      IF(IGO.EQ.0) GO TO 5
      GO TO 1
5     STOP
      END
```

APPENDIX 7

++DATA FILE: 4UP1 ++DATE:22-JAN-87

FIRST RUN AT 4 DEGREES WITH SQUARE SAIL

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.13	0.21	2295.3	0.00	3.620	0.00	5.688
1.26	1.34	21534.4	-0.01	-0.187	-0.00	-0.083
2.05	2.29	35113.4	-0.02	-0.165	-0.01	-0.580
3.79	4.04	64957.0	-0.04	-0.131	-0.02	-0.407
4.62	4.98	79170.2	-0.07	-0.135	-0.04	-0.457
5.78	5.92	99030.9	-0.11	-0.136	-0.07	-0.514
6.27	6.53	107374.9	-0.13	-0.139	-0.09	-0.540
7.30	7.57	125074.4	-0.18	-0.141	-0.12	-0.560
7.74	7.99	132642.1	-0.20	-0.141	-0.14	-0.567
8.25	8.58	141355.4	-0.23	-0.143	-0.16	-0.590
8.83	9.21	151319.1	-0.26	-0.143	-0.19	-0.596
9.25	9.59	158576.1	-0.29	-0.143	-0.21	-0.596
9.97	10.24	170920.7	-0.34	-0.144	-0.25	-0.608
10.39	10.74	177983.5	-0.36	-0.143	-0.26	-0.600
11.81	12.13	202399.6	-0.47	-0.143	-0.35	-0.625
12.60	13.06	215869.7	-0.53	-0.141	-0.41	-0.630
13.26	13.69	227190.7	-0.59	-0.142	-0.46	-0.643
13.78	14.13	236213.4	-0.63	-0.139	-0.49	-0.634
14.81	15.28	253857.5	-0.71	-0.137	-0.57	-0.634
15.84	16.32	271464.3	-0.80	-0.135	-0.65	-0.639
16.94	17.35	290356.7	-0.91	-0.134	-0.75	-0.643
17.52	18.08	300269.5	-0.98	-0.134	-0.81	-0.648
19.82	20.44	339729.8	-1.27	-0.136	-1.04	-0.651
20.97	21.24	359372.3	-1.43	-0.137	-1.17	-0.654
22.36	23.10	383164.4	-1.58	-0.133	-1.30	-0.643
25.98	26.68	445265.2	-2.18	-0.136	-1.82	-0.664
26.79	27.55	459150.5	-2.27	-0.133	-1.88	-0.644
0.65	0.90	11221.6	0.06	6.278	0.01	4.524
999.99	999.9	999.99	99.99	999.99	99.99	999.99

99.99

++DATA FILE: 4DN1 ++DATE:22-JAN-87

FIRST RUN DOWN AT 4 DGREES WITH SQUARE SAIL

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.07	0.30	1133.0	0.00	36.543	0.00	26.684
26.93	27.64	461517.0	-2.35	-0.137	-1.92	-0.652
24.90	25.61	426730.8	-1.98	-0.135	-1.64	-0.653
23.68	24.23	405847.4	-1.80	-0.135	-1.49	-0.655
23.03	23.39	394718.3	-1.65	-0.131	-1.38	-0.639
22.37	22.88	383374.6	-1.58	-0.133	-1.31	-0.644
21.22	21.70	363613.7	-1.39	-0.130	-1.15	-0.632
20.12	20.82	344887.1	-1.28	-0.133	-1.06	-0.642
19.58	20.55	335633.6	-1.21	-0.133	-1.00	-0.643
19.03	19.98	326059.2	-1.15	-0.134	-0.95	-0.644
17.44	17.75	298856.3	-0.98	-0.136	-0.80	-0.649
16.86	17.07	288889.8	-0.93	-0.178	-0.76	-0.655
15.27	15.75	261612.2	-0.77	-0.138	-0.61	-0.644
13.81	14.15	236652.6	-0.65	-0.144	-0.50	-0.651
13.36	13.71	229029.7	-0.61	-0.143	-0.46	-0.640
12.44	12.67	213264.7	-0.54	-0.147	-0.41	-0.649

9.36	9.61	160488.5	-0.32	-0.155	-0.23	-0.636
8.50	8.96	145622.0	-0.26	-0.150	-0.18	-0.625
8.01	8.10	137330.1	-0.23	-0.149	-0.16	-0.628
6.96	7.21	119217.5	-0.16	-0.140	-0.12	-0.587
4.97	5.17	85140.1	-0.08	-0.129	-0.06	-0.584
2.33	2.39	39912.6	-0.01	-0.112	-0.01	-0.643
0.44	3.62	7466.9	0.02	4.748	0.00	3.610

++DATA FILE: 9UP1 ++DATE:22-JAN-87

FIRST RUN UP AT 9 DEGREES

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.19	1.72	3288.9	0.00	5.017	-0.00	-2.772
3.53	-5.17	60508.2	-0.11	-0.366	-0.08	-1.506
4.29	3.98	73453.5	-0.16	-0.375	-0.11	-1.541
5.99	4.02	102581.4	-0.31	-0.368	-0.23	-1.558
7.03	3.94	120560.8	-0.41	-0.352	-0.31	-1.554
8.17	3.97	139936.3	-0.54	-0.343	-0.43	-1.576
8.81	3.88	150914.7	-0.63	-0.341	-0.51	-1.604
10.40	10.39	178228.2	-0.83	-0.323	-0.71	-1.615
11.60	11.75	198722.4	-1.00	-0.312	-0.87	-1.599
12.64	12.78	216614.3	-1.19	-0.313	-1.04	-1.607
14.21	14.47	243608.1	-1.53	-0.320	-1.33	-1.621
15.26	15.53	261496.1	-1.77	-0.320	-1.52	-1.604
16.32	16.61	279650.2	-2.03	-0.320	-1.72	-1.594
17.34	17.66	297230.0	-2.34	-0.328	-1.95	-1.596
18.47	18.78	316597.0	-2.73	-0.337	-2.21	-1.597
19.63	19.94	336398.7	-3.10	-0.339	-2.47	-1.578
20.83	21.09	356917.5	-3.58	-0.348	-2.79	-1.586
21.54	21.92	369116.6	-3.86	-0.350	-2.99	-1.585
23.01	23.31	394348.2	-4.34	-0.346	-3.35	-1.556
24.36	24.60	417405.4	-5.06	-0.359	-3.82	-1.584
25.06	25.37	429425.7	-5.38	-0.361	-4.02	-1.575
25.98	26.29	445202.4	-5.69	-0.355	-4.24	-1.546
25.98	26.27	445152.0	-5.71	-0.356	-4.27	-1.557
26.82	27.11	459557.1	-6.17	-0.361	-4.58	-1.568
0.44	-5.39	7604.6	0.08	17.755	-0.00	-3.703
999.99	999.0	999.99	99.99	999.99	99.99	999.99

99.99 ++DATA FILE: 9DN1 ++DATE:22-JAN-87

FIRST RUN DOWN AT 9 DEGREES FZERO-2.0 ZMO-1.0

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.29	-3.24	4996.3	0.00	0.264	[illegible]	-1.373
25.97	26.43	445072.4	-5.58	-0.349	-4.22	-1.541
24.01	24.35	411482.6	-4.70	-0.343	-3.62	-1.545
22.65	22.97	388133.3	-4.14	-0.340	-3.23	-1.551
20.86	21.21	357438.3	-3.43	-0.332	-2.75	-1.554
19.28	19.65	330466.3	-2.87	-0.325	-2.35	-1.558
17.63	17.84	302060.6	-2.33	-0.315	-1.98	-1.570
15.96	16.21	273512.1	-1.85	-0.306	-1.63	-1.577
14.86	15.14	254612.7	-1.61	-0.306	-1.43	-1.591
13.36	13.56	229023.3	-1.29	-0.304	-1.16	-1.596
12.05	12.13	206471.9	-1.06	-0.307	-0.95	-1.613
10.86	10.98	186138.1	-0.89	-0.314	-0.78	-1.626
9.07	9.31	155410.2	-0.64	-0.325	-0.54	-1.622
7.12	7.17	122031.0	-0.43	-0.355	-0.33	-1.599
3.97	3.92	67984.5	-0.16	-0.433	-0.10	-1.560
2.34	2.26	40151.5	-0.06	-0.453	-0.03	[illegible]
999.99	99.99	999.99	99.99	999.99	99.99	[illegible]

99.99

++DATA FILE: SIS15 ++DATE:20-JAN-87

FIRSY

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
4.15	4.31	71049.2	-0.12	-0.292	-0.08	-1.155
6.01	5.93	102985.0	-0.25	-0.293	-0.18	-1.206
7.49	7.71	128431.1	-0.41	-0.304	-0.29	-1.288
9.38	9.55	160675.3	-0.68	-0.325	-0.50	-1.393
12.33	12.55	211278.0	-1.80	-0.500	-1.50	-2.432
14.83	15.01	254109.6	-2.51	-0.481	-2.23	-2.495
17.02	17.19	291645.5	-3.21	-0.467	-2.95	-2.511
19.84	20.02	339940.2	-4.38	-0.469	-3.98	-2.493
21.65	21.93	371056.1	-5.41	-0.486	-4.75	-2.495
23.87	23.92	409114.5	-6.70	-0.495	-5.74	-2.478
26.13	26.21	447815.4	-8.17	-0.504	-6.82	-2.461
27.02	27.25	462980.5	-8.89	-0.513	-7.33	-2.472
26.90	27.01	460947.8	-8.75	-0.510	-7.23	-2.460
26.90	27.04	460981.6	-8.79	-0.512	-7.25	-2.469
26.89	27.12	460830.3	-8.78	-0.511	-7.24	-2.464
26.88	27.15	460623.0	-8.73	-0.509	-7.19	-2.449
25.43	25.64	435856.4	-7.74	-0.504	-6.50	-2.473
23.65	23.85	405327.5	-6.53	-0.492	-5.62	-2.474
22.35	22.65	383094.6	-5.79	-0.488	-5.07	-2.497
21.04	21.28	360499.9	-5.04	-0.480	-4.50	-2.506
19.54	19.82	334808.8	-4.23	-0.467	-3.89	-2.508
17.73	17.94	303831.4	-3.42	-0.459	-3.24	-2.540
16.17	16.20	277185.0	-2.84	-0.457	-2.68	-2.525
14.46	14.53	247770.5	-2.31	-0.466	-2.12	-2.500
12.91	13.11	221173.6	-1.90	-0.481	-1.68	-2.490
11.14	11.27	190968.7	-1.50	-0.508	-1.24	-2.468
9.74	9.80	166865.0	-1.19	-0.529	-0.92	-2.398
7.91	8.07	135578.5	-0.83	-0.557	-0.60	-2.342
6.41	6.51	109789.1	-0.57	-0.583	-0.38	-2.306
4.60	4.84	78785.0	-0.34	-0.670	-0.19	-2.256
2.67	2.85	45785.3	-0.12	-0.696	-0.02	-0.825
4.80	5.01	82206.7	-0.23	-0.413	-0.11	-1.169
6.46	6.65	110790.0	-0.36	-0.367	-0.22	-1.274
8.33	8.51	142721.7	-0.93	-0.563	-0.65	-2.319
9.83	9.93	168399.3	-1.23	-0.535	-0.93	-2.363
11.48	11.62	196660.2	-1.57	-0.503	-1.28	-2.402
12.96	13.13	222049.1	-1.97	-0.493	-1.69	-2.485
14.47	14.68	248060.4	-2.38	-0.479	-2.12	-2.496
16.03	16.27	274769.1	-2.88	-0.471	-2.63	-2.520
17.70	17.92	303296.9	-3.44	-0.463	-3.20	-2.516
19.45	19.67	333266.7	-4.26	-0.474	-3.85	-2.505
20.80	20.78	356390.3	-4.96	-0.484	-4.38	-2.497
22.61	22.29	387404.3	-5.96	-0.492	-5.14	-2.477
24.04	24.18	411911.2	-6.79	-0.495	-5.79	-2.470
26.20	26.39	448927.8	-8.23	-0.505	-6.86	-2.462
27.01	27.15	462944.7	-8.89	-0.513	-7.30	-2.464
27.02	27.32	462980.5	-8.90	-0.514	-7.31	-2.465
27.01	27.26	462947.7	-8.92	-0.515	-7.31	-2.465
999.99	999.99	999.99	999.99	999.99	999.99	999.99
999.99						

++DATA FILE: 2SIS15 ++DATE:21-JAN-87

SECOND RUN AT 15 TRYING TO FIND HYSTERISIS LOOP

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
3.55	3.43	60862.0	-0.07	-0.247	-0.05	-1.013
3.61	3.61	61891.3	-0.08	-0.259	-0.06	-1.068
4.32	4.34	74081.2	-0.11	-0.259	-0.08	-1.096
4.93	4.96	84511.0	-0.16	-0.273	-0.11	-1.161
5.70	5.67	97671.1	-0.40	-0.525	-0.30	-2.247
6.26	6.32	107229.9	-0.49	-0.529	-0.36	-2.273
6.95	7.04	119023.2	-0.61	-0.530	-0.45	-2.289
7.55	7.73	129374.5	-0.72	-0.530	-0.53	-2.307
8.21	8.51	140637.2	-0.84	-0.526	-0.63	-2.313
8.81	9.14	150936.5	-0.96	-0.522	-0.74	-2.342
9.67	9.63	165710.0	-1.15	-0.517	-0.90	-2.372
11.45	11.57	196220.2	-1.56	-0.503	-1.30	-2.444
12.87	13.03	220569.0	-1.93	-0.491	-1.67	-2.479
15.10	15.23	258716.6	-2.56	-0.474	-2.32	-2.510
17.29	17.53	296274.1	-3.28	-0.462	-3.09	-2.542
19.54	19.82	334786.4	-4.30	-0.475	-3.93	-2.534
21.75	21.96	372718.9	-5.49	-0.489	-4.80	-2.500
21.73	21.96	372461.9	-5.49	-0.490	-4.80	-2.500
23.62	23.91	404868.7	-6.74	-0.509	-5.64	-2.490
26.53	26.80	454682.2	-8.76	-0.524	-7.07	-2.473
24.76	25.01	424250.2	-7.52	-0.517	-6.18	-2.482
22.03	22.32	377594.4	-5.72	-0.496	-4.89	-2.480
20.46	20.70	350647.3	-4.84	-0.487	-4.23	-2.487
18.82	19.00	322458.2	-4.00	-0.476	-3.60	-2.505
16.70	16.88	286133.6	-3.05	-0.460	-2.85	-2.517
14.61	14.82	250382.0	-2.34	-0.463	-2.17	-2.498
12.77	12.98	218882.5	-1.84	-0.475	-1.62	-2.449
12.21	12.30	209214.2	-1.69	-0.479	-1.47	-2.431
11.46	11.56	196468.5	-1.52	-0.489	-1.28	-2.399
10.93	11.03	187254.4	-1.41	-0.496	-1.15	-2.382
10.37	10.38	177639.5	-1.28	-0.504	-1.04	-2.373
9.58	9.63	164257.0	-1.10	-0.504	[illegible]	-2.316
9.09	9.28	155703.5	-0.98	-0.501	-0.76	-2.277
8.39	8.71	143858.1	-0.87	-0.517	-0.6[illegible]	-2.269
7.75	7.88	132881.6	-0.77	-0.536	-0.54	-2.214
7.17	7.26	122926.6	-0.67	-0.546	-0.45	-2.143
6.44	6.48	110399.5	-0.55	-0.563	-0.35	-2.052
5.69	5.71	97445.6	-0.45	-0.588	-0.26	-1.957
5.22	5.29	89416.2	-0.40	-0.614	-0.21	-1.893
4.44	4.48	76026.8	-0.31	-0.674	-0.14	-1.707
3.80	3.82	65070.2	-0.25	-0.732	-0.08	-1.383
3.38	3.39	57929.3	-0.21	-0.787	-0.05	-1.133
2.73	2.74	46773.6	-0.16	-0.928	-0.01	-0.491
999.99	999.99	999.9	999.99	999.99	999.99	999.99

99.99

++DATA FILE: 3SIS15 ++DATE:21-JAN-87
STARTING AT 13 FT/SEC DECREASING BEFORE ZERO SHIFTS

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
12.86	13.00	220469.4	-1.80	-0.457	-1.67	-2.486
12.21	12.41	209292.2	-1.64	-0.464	-1.52	-2.504
11.48	11.64	196686.1	-1.46	-0.466	-1.32	-2.476
10.89	10.94	186622.7	-1.34	-0.475	-1.20	-2.492
10.25	10.31	175674.7	-1.19	-0.475	-1.06	-2.475
9.59	9.58	164307.3	-1.03	-0.473	-0.91	-2.439
9.01	9.24	154337.0	-0.90	-0.467	-0.80	-2.421
8.43	8.79	144422.8	-0.80	-0.476	-0.70	-2.415
7.61	7.78	130478.5	-0.68	-0.491	-0.56	-2.363
7.06	7.16	120958.5	-0.59	-0.503	-0.47	-2.341
6.40	6.49	109656.9	-0.50	-0.512	-0.39	-2.319
5.74	5.79	98396.8	-0.41	-0.523	-0.30	-2.278
5.23	5.26	89639.3	-0.34	-0.523	-0.25	-2.228
4.38	4.34	75132.7	-0.25	-0.540	-0.17	-2.162
3.71	3.71	63564.8	-0.17	-0.533	-0.11	-2.047
3.33	3.33	57010.2	-0.14	-0.549	-0.09	-1.998
2.62	2.64	44861.8	-0.09	-0.550	-0.05	-1.715
1.70	1.65	29157.4	-0.03	-0.495	-0.00	-0.106
1.48	1.41	25362.9	-0.03	-0.493	0.00	0.193
0.63	0.26	10714.4	-0.01	-1.584	0.01	3.619
1.10	0.84	18840.4	-0.02	-0.562	0.00	0.760
2.04	2.05	35007.0	-0.03	-0.315	-0.01	-0.524
2.44	2.53	41774.1	-0.04	-0.263	-0.02	-0.646
2.87	2.95	49248.6	-0.05	-0.264	-0.02	-0.740
2.87	2.90	49212.9	-0.05	-0.273	-0.03	-0.776
3.55	3.64	60877.3	-0.08	-0.269	-0.05	-0.923
3.81	3.92	65272.3	-0.09	-0.275	-0.06	-0.996
4.45	4.58	76184.1	-0.12	-0.266	-0.08	-1.006
5.19	5.32	88984.2	-0.19	-0.290	-0.13	-1.156
5.80	5.90	99364.9	-0.25	-0.308	-0.17	-1.262
6.58	6.67	112843.7	-0.53	-0.519	-0.40	-2.264
7.23	7.38	123941.2	-0.63	-0.506	-0.49	-2.286
7.69	7.87	131831.2	-0.70	-0.497	-0.56	-2.325
8.37	8.64	143463.9	-0.80	-0.481	-0.67	-2.365
9.05	9.29	155140.4	-0.93	-0.480	-0.80	-2.409
9.51	9.58	162943.7	-1.02	-0.474	-0.88	-2.408
10.47	10.58	179478.8	-1.22	-0.468	-1.08	-2.419
10.89	11.04	186671.2	-1.33	-0.471	-1.18	-2.441
11.72	11.91	200849.9	-1.52	-0.467	-1.38	-2.469
12.31	12.42	210932.5	-1.68	-0.467	-1.54	-2.502
12.97	13.15	222325.7	-1.84	-0.460	-1.71	-2.495
12.34	12.55	211472.4	-1.65	-0.456	-1.52	-2.466
11.43	11.62	195929.3	-1.44	-0.465	-1.32	-2.477
10.90	11.08	186853.0	-1.32	-0.468	-1.19	-2.460
10.23	10.32	175308.0	-1.17	-0.471	-1.03	-2.421
9.59	9.63	164295.7	-1.03	-0.473	-0.89	-2.393
8.94	9.18	153232.8	-0.91	-0.478	-0.77	-2.387
8.15	8.30	139725.2	-0.76	-0.482	-0.64	-2.359
7.58	7.71	129829.9	-0.66	-0.481	-0.53	-2.288
7.06	7.15	120978.1	-0.58	-0.489	-0.46	-2.274
6.33	6.43	108540.0	-0.48	-0.509	-0.37	-2.252
5.86	5.97	100472.3	-0.42	-0.518	-0.31	-2.212
5.17	5.20	88529.5	-0.34	-0.543	-0.23	-2.147

3.23	3.25	55290.4	-0.14	-0.585	-0.07	-1.660
2.56	2.58	43948.9	-0.10	-0.617	-0.03	-1.257
2.54	2.55	43597.5	-0.10	-0.630	-0.03	-1.287
2.54	2.58	43520.4	-0.09	-0.607	-0.03	-1.273
2.52	2.56	43217.6	-0.09	-0.598	-0.03	-1.296
0.29	0.88	4996.5	-0.02	-11.898	0.02	48.725
999.99	999.9	999.99	999.99	999.99	999.99	999.99
99.99						

++DATA FILE: 4UP1R ++DATE:22-JAN-87
FIRST RUN AT 4 DEGREES WITH ROUNDED SAIL

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.40	0.36	6881.4	0.00	0.558	0.00	1.086
3.06	3.17	52367.7	-0.03	-0.134	-0.02	-0.448
4.49	4.73	76952.7	-0.07	-0.145	-0.04	-0.436
5.97	6.37	102307.5	-0.13	-0.150	-0.06	-0.445
7.82	8.13	133936.8	-0.22	-0.150	-0.11	-0.448
8.65	9.05	148286.8	-0.28	-0.155	-0.15	-0.477
9.09	9.38	155856.9	-0.31	-0.158	-0.16	-0.485
10.48	10.78	179545.5	-0.41	-0.159	-0.22	-0.492
10.94	11.28	187511.8	-0.44	-0.156	-0.24	-0.488
11.93	12.31	204421.8	-0.54	-0.161	-0.29	-0.503
12.69	13.07	217470.3	-0.63	-0.164	-0.34	-0.516
13.32	13.70	228274.8	-0.67	-0.159	-0.36	-0.499
13.80	14.20	236513.7	-0.73	-0.160	-0.39	-0.506
14.79	15.24	253517.1	-0.85	-0.163	-0.46	-0.516
15.36	15.87	263219.3	-0.91	-0.162	-0.49	-0.514
15.89	16.43	272311.2	-0.96	-0.160	-0.52	-0.507
17.01	17.52	291459.2	-1.12	-0.163	-0.61	-0.516
17.52	18.28	300207.3	-1.19	-0.163	-0.64	-0.514
18.10	19.07	310272.3	-1.26	-0.162	-0.68	-0.511
19.24	19.88	329750.4	-1.46	-0.166	-0.79	-0.522
19.84	20.46	340067.2	-1.59	-0.170	-0.86	-0.535
22.50	22.65	385578.3	-1.98	-0.165	-1.06	-0.514
23.22	23.43	397849.9	-2.06	-0.161	-1.10	-0.504
23.88	24.56	409263.3	-2.22	-0.164	-1.19	-0.515
25.28	25.92	433205.1	-2.50	-0.165	-1.34	-0.518
26.07	26.52	446696.8	-2.68	-0.166	-1.44	-0.523
26.95	27.70	461938.3	-2.85	-0.165	-1.53	-0.519
26.65	27.24	456635.7	-2.77	-0.164	-1.50	-0.521
24.51	25.18	420112.6	-2.33	-0.163	-1.27	-0.522
0.75	-0.41	12917.4	0.06	4.430	-0.01	-2.618
999.99	9.9	9.9	9.9	9.9	9.9	9.9

99.99

++DATA FILE: 4DN1R ++DATE:22-JAN-87

FIRST RUN DOWN AT 4 DEGREES WITH ROUNDED SAIL

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.23	0.27	3933.6	0.00	0.996	0.00	5.814
26.27	27.14	450125.4	-2.74	-0.167	-1.45	-0.517
24.72	25.53	423711.3	-2.41	-0.166	-1.28	-0.514
23.63	24.33	404952.2	-2.13	-0.161	-1.13	-0.499
21.79	22.42	373410.0	-1.84	-0.163	-0.98	-0.510
20.64	21.17	353683.7	-1.65	-0.163	-0.88	-0.511
19.58	20.95	335535.1	-1.49	-0.163	-0.80	-0.513
18.42	19.28	315709.9	-1.31	-0.163	-0.71	-0.512
17.37	17.81	297621.9	-1.13	-0.158	-0.61	-0.496
16.39	16.80	280842.8	-1.04	-0.164	-0.56	-0.518
15.89	15.90	272278.3	-0.96	-0.161	-0.52	-0.510
15.34	15.54	262892.6	-0.90	-0.161	-0.49	-0.510
14.91	15.26	255549.0	-0.84	-0.160	-0.46	-0.506
14.42	14.77	247199.6	-0.78	-0.159	-0.43	-0.505
13.39	13.64	229481.5	-0.67	-0.157	-0.37	-0.503
12.49	12.90	214096.6	-0.59	-0.160	-0.33	-0.513
11.80	12.17	202291.1	-0.53	-0.160	-0.29	-0.514
11.23	11.54	192387.7	-0.47	-0.158	-0.26	-0.510
9.84	10.04	168592.5	-0.37	-0.160	-0.20	-0.518
9.18	9.61	157279.0	-0.31	-0.156	-0.17	-0.510
8.55	9.21	146576.5	-0.26	-0.150	-0.15	-0.498
7.89	7.93	135154.8	-0.22	-0.148	-0.12	-0.488
7.02	7.15	120244.5	-0.17	-0.148	-0.10	-0.495
5.87	6.01	100586.8	-0.12	-0.143	-0.07	-0.495
5.71	5.93	97854.5	-0.10	-0.135	-0.06	-0.469
4.97	5.19	85136.6	-0.07	-0.119	-0.05	-0.464
3.55	3.57	60807.6	-0.02	-0.072	-0.02	-0.329
2.32	2.39	39774.1	0.00	0.003	-0.01	-0.322
0.66	[illegible]	11244.9	0.03	2.674	0.00	2.439
999.99	9.9	9.9	9.9	9.9	9.9	9.9

99.99

++DATA FILE: 9UP1R   ++DATE:22-JAN-87
FIRST RUN UP AT 9 DEGREES WITH ROUNDED SAIL

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.29	0.29	5029.9	0.00	0.667	0.00	2.032
2.18	2.32	37385.0	-0.02	-0.179	-0.01	-0.533
4.41	4.73	75498.7	-0.15	-0.315	-0.08	-1.060
5.40	5.62	92468.2	-0.27	-0.386	-0.15	-1.273
5.44	5.71	93162.4	-0.28	-0.397	-0.16	-1.327
6.93	7.19	118760.0	-0.44	-0.389	-0.25	-1.296
7.38	7.68	126438.9	-0.50	-0.384	-0.28	-1.279
7.96	8.28	136439.0	-0.58	-0.387	-0.33	-1.291
8.73	9.08	149646.1	-0.70	-0.387	-0.40	-1.287
9.36	9.63	160421.6	-0.79	-0.382	-0.45	-1.273
10.07	10.38	172613.9	-0.93	-0.386	-0.53	-1.288
11.00	11.35	188453.9	-1.09	-0.380	-0.62	-1.271
12.05	12.43	206473.0	-1.33	-0.385	-0.76	-1.282
12.92	13.35	221338.3	-1.51	-0.382	-0.86	-1.270
13.96	14.37	239217.9	-1.77	-0.382	-1.00	-1.268
15.05	15.46	257861.6	-2.07	-0.385	-1.18	-1.283
16.06	16.46	275224.4	-2.35	-0.385	-1.34	-1.280
17.15	17.61	293901.3	-2.70	-0.386	-1.54	-1.285
18.90	19.20	323828.3	-3.27	-0.385	-1.86	-1.283
19.41	19.95	332558.6	-3.44	-0.385	-1.96	-1.283
20.61	21.09	353272.3	-3.90	-0.387	-2.22	-1.288
21.86	22.35	374549.2	-4.39	-0.387	-2.50	-1.289
23.25	19.62	398511.9	-4.99	-0.388	-2.84	-1.294
24.60	19.52	421637.1	-5.59	-0.389	-3.18	-1.295
26.14	7.78	448020.9	-6.33	-0.390	-3.60	-1.298
26.42	27.20	452767.3	-6.34	-0.383	-3.63	-1.280
25.01	25.54	428577.9	-5.66	-0.381	-3.24	-1.277
0.78	1.11	13443.6	0.04	2.812	-0.01	-4.479
999.99	9.9	9.9	9.9	9.9	9.9	9.9
99.99						

++DATA FILE: 9DN1R ++DATE:22-JAN-87

FIRST RUN DOWN AT 9 DEGREES WITH ROUNDED SAIL

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.15	0.15	2574.3	0.00	3.652	0.00	9.049
26.32	27.03	450976.4	-6.39	-0.389	-3.61	-1.285
25.09	25.70	429894.4	-5.77	-0.386	-3.27	-1.280
23.85	24.39	408715.3	-5.19	-0.384	-2.95	-1.277
22.51	23.13	385727.5	-4.63	-0.385	-2.64	-1.281
21.33	20.68	365626.7	-4.17	-0.386	-2.38	-1.286
20.17	20.39	345629.8	-3.73	-0.387	-2.13	-1.292
19.07	19.71	326787.1	-3.32	-0.385	-1.90	-1.286
17.27	17.68	295935.6	-2.71	-0.383	-1.55	-1.282
16.39	16.78	280939.9	-2.44	-0.383	-1.40	-1.282
15.36	15.60	263187.2	-2.13	-0.381	-1.22	-1.278
13.92	14.21	238475.9	-1.76	-0.383	-1.01	-1.286
12.53	12.79	214681.1	-1.40	-0.375	-0.81	-1.266
11.22	11.53	192228.1	-1.14	-0.381	-0.66	-1.291
9.85	10.07	168846.2	-0.87	-0.376	-0.50	-1.279
8.54	8.77	146437.8	-0.65	-0.373	-0.38	-1.286
7.50	7.73	128572.9	-0.51	-0.380	-0.30	-1.308
6.08	6.25	104142.4	-0.33	-0.372	-0.20	-1.317
4.99	5.13	85455.8	-0.21	-0.361	-0.13	-1.320
0.72	0.92	12350.4	0.02	1.250	0.00	0.421
999.99	9.9	9.9	9.9	9.9	9.9	9.9
99.99						

++DATA FILE: 15UP1R ++DATE:23-JAN-87

FIRST RUN UP AT 15 DEGREES WITH ROUNDED SAIL

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.13	1.22	2258.8	0.01	13.663	0.00	11.751
3.72	-1.14	63831.8	-0.08	-0.247	-0.05	-0.815
6.14	-2.85	105289.5	-0.25	-0.281	-0.16	-1.037
7.13	0.96	122169.6	-0.34	-0.285	-0.22	-1.062
7.20	7.18	123317.4	-0.38	-0.307	-0.24	-1.158
9.00	9.26	154252.5	-1.02	-0.532	-0.63	-1.914
10.12	9.80	173443.4	-1.30	-0.535	-0.80	-1.923
11.23	11.01	192460.4	-1.60	-0.536	-0.99	-1.933
12.47	12.61	213637.2	-1.99	-0.539	-1.23	-1.942
13.49	13.65	231198.3	-2.32	-0.537	-1.43	-1.936
15.08	15.24	258461.8	-2.93	-0.543	-1.80	-1.950
16.11	16.27	276126.3	-3.32	-0.539	-2.04	-1.938
17.23	17.46	295222.8	-3.79	-0.539	-2.33	-1.931
18.36	18.54	314642.2	-4.31	-0.538	-2.64	-1.931
19.40	19.62	332544.5	-4.82	-0.540	-2.96	-1.934
20.59	20.62	352879.8	-5.41	-0.537	-3.32	-1.928
21.81	21.90	373697.4	-6.05	-0.536	-3.71	-1.923
22.51	22.62	385799.1	-6.49	-0.540	-3.99	-1.938
23.89	24.05	409390.3	-7.34	-0.542	-4.50	-1.941
24.59	24.70	421432.9	-7.71	-0.537	-4.73	-1.926
25.31	25.55	433674.7	-8.19	-0.539	-5.03	-1.934
26.15	26.13	448192.5	-8.72	-0.537	-5.35	-1.925
26.53	26.60	454592.9	-8.91	-0.534	-5.49	-1.921
0.93	-4.09	15971.7	0.02	1.130	-0.00	-1.058
999.99	9.9	9.9	9.9	9.9	9.9	9.9
99.99						

++DATA FILE: 15DN1R ++DATE:23-JAN-87

FIRST RUN DOWN AT 15 DEGREES WITH ROUNDED SAIL

VFREE (FT/SEC)	VLASER (FT/SEC)	REYNLD	RFOR (LB)	CFOR	RMOM (INLB)	CMOM
0.11	-2.62	1940.3	0.01	24.369	0.00	32.985
26.65	27.11	456762.9	-9.10	-0.540	-5.59	-1.936
26.15	26.48	448204.5	-8.82	-0.543	-5.42	-1.950
24.79	25.11	423598.5	-7.82	-0.536	-4.81	-1.927
23.62	23.92	404786.9	-7.08	-0.534	-4.36	-1.923
23.03	23.39	394589.2	-6.77	-0.538	-4.17	-1.936
22.38	22.69	383508.3	-6.39	-0.538	-3.94	-1.937
21.40	21.69	366751.8	-5.83	-0.536	-3.60	-1.938
20.80	21.01	356495.3	-5.50	-0.536	-3.40	-1.933
19.68	20.01	337297.8	-4.96	-0.539	-3.07	-1.951
18.69	18.98	320334.6	-4.47	-0.539	-2.77	-1.949
18.09	18.32	309954.7	-4.17	-0.537	-2.59	-1.948
17.57	17.89	301084.0	-3.92	-0.535	-2.43	-1.940
15.55	15.83	266543.1	-3.07	-0.536	-1.91	-1.948
14.52	14.77	248903.7	-2.67	-0.533	-1.66	-1.944
13.43	13.63	230079.1	-2.28	-0.532	-1.43	-1.952
12.15	12.28	208230.2	-1.84	-0.525	-1.16	-1.936
11.19	11.32	191829.1	-1.56	-0.525	-0.99	-1.945
10.30	10.47	176580.4	-1.31	-0.519	-0.83	-1.933
9.36	9.53	160462.6	-1.08	-0.517	-0.69	-1.934
8.54	8.69	146278.2	-0.88	-0.509	-0.57	-1.917
7.60	7.74	130255.9	-0.68	-0.495	-0.45	-1.897
6.51	6.63	111556.1	-0.38	-0.380	-0.27	-1.544
5.19	5.27	89028.0	-0.15	-0.228	-0.12	-1.055
4.45	4.49	76201.9	-0.10	-0.208	-0.09	-1.077
0.68	0.71	11568.0	0.04	3.756	0.00	1.088
999.99	9.9	9.9	9.9	9.9	9.9	9.9
99.99						

APPENDIX 8

DATA FILE: SORP35 DATE:27-FEB-87
.35" STAND-OFF
YAW ANGLE=14.0 XM FROM BOW=12.92

XM	YM	ZM	ROTATION	VLASER	VFREE	RATIO	PERCENT
12.9200	0.0000	1.6975	0.0	0.982	25.043	0.0392	
12.9200	0.1332	1.6923	4.5	0.723	25.010	0.0289	
12.9200	0.2655	1.6766	9.0	0.652	25.020	0.0261	
12.9200	0.3963	1.6506	13.5	0.485	25.010	0.0194	
12.9200	0.5246	1.6144	18.0	0.439	25.004	0.0175	
12.9200	0.6496	1.5683	22.5	0.326	25.016	0.0130	
12.9200	0.7706	1.5125	27.0	0.173	25.017	0.0069	
12.9200	0.8869	1.4474	31.5	-0.114	25.027	-0.0046	
12.9200	0.9978	1.3733	36.0	0.044	25.024	0.0018	
12.9200	1.1024	1.2908	40.5	0.633	25.053	0.0253	
12.9200	1.2003	1.2003	45.0	1.199	25.055	0.0479	
12.9200	1.2908	1.1024	49.5	1.039	25.068	0.0414	
12.9200	1.3733	0.9978	54.0	1.264	25.070	0.0504	
12.9200	1.4474	0.8869	58.5	1.345	25.079	0.0536	
12.9200	1.5125	0.7706	63.0	0.727	25.102	0.0290	
12.9200	1.5683	0.6496	67.5	0.401	25.104	0.0160	
12.9200	1.6144	0.5246	72.0	0.273	25.118	0.0109	
12.9200	1.6506	0.3963	76.5	1.192	25.130	0.0474	
12.9200	1.6766	0.2655	81.0	0.546	25.149	0.0217	
12.9200	1.6923	0.1332	85.5	0.654	25.157	0.0260	
12.9200	1.6975	0.0000	90.0	0.459	25.173	0.0182	
12.9200	1.6923	-0.1332	94.5	0.224	25.189	0.0089	
12.9200	1.6766	-0.2655	99.0	-0.019	25.203	-0.0008	
12.9200	1.6506	-0.3963	103.5	-0.224	25.198	-0.0089	
12.9200	1.6144	-0.5246	108.0	-0.506	25.203	-0.0201	
12.9200	1.5683	-0.6496	112.5	-0.615	25.205	-0.0244	
12.9200	1.5125	-0.7706	117.0	-0.759	25.206	-0.0301	
12.9200	1.4474	-0.8869	121.5	-0.813	25.199	-0.0323	
12.9200	1.3733	-0.9978	126.0	-0.880	25.211	-0.0349	
12.9200	1.2908	-1.1024	130.5	-0.947	25.221	-0.0376	
12.9200	1.2003	-1.2003	135.0	-0.903	25.218	-0.0358	
12.9200	1.1024	-1.2908	139.5	-0.925	25.218	-0.0367	
12.9200	0.9978	-1.3733	144.0	-0.850	25.219	-0.0337	
12.9200	0.8869	-1.4474	148.5	-0.680	25.213	-0.0270	
12.9200	0.7706	-1.5125	153.0	-0.565	25.216	-0.0224	
12.9200	0.6496	-1.5683	157.5	-0.421	25.215	-0.0167	
12.9200	0.5246	-1.6144	162.0	-0.206	25.211	-0.0082	
12.9200	0.3963	-1.6506	166.5	-0.057	25.189	-0.0023	
12.9200	0.2655	-1.6766	171.0	0.239	25.188	0.0095	
12.9200	0.1332	-1.6923	175.5	0.445	25.193	0.0177	
12.9200	0.0000	-1.6975	180.0	0.795	25.182	0.0316	
12.9200	-0.1332	-1.6923	184.5	1.013	25.186	0.0402	
12.9200	-0.2655	-1.6766	189.0	1.259	25.192	0.0500	
12.9200	-0.3963	-1.6506	193.5	1.527	25.194	0.0606	
12.9200	-0.5246	-1.6144	198.0	1.796	25.198	0.0713	
12.9200	-0.6496	-1.5683	202.5	2.042	25.202	0.0810	
12.9200	-0.7706	-1.5125	207.0	2.287	25.201	0.0908	
12.9200	-0.8869	-1.4474	211.5	2.503	25.204	0.0993	
12.9200	-0.9978	-1.3733	216.0	2.756	25.038	0.1101	
12.9200	-1.1024	-1.2908	220.5	2.977	25.037	0.1189	
12.9200	-1.2003	-1.2003	225.0	3.159	25.029	0.1262	
12.9200	-1.2908	-1.1024	229.5	3.323	25.038	0.1327	
12.9200	-1.3733	-0.9978	234.0	3.562	25.018	0.1424	

12.9200	-1.4474	-0.8869	238.5	3.664	25.025	0.1464
12.9200	-1.5125	-0.7706	243.0	3.784	25.030	0.1512
12.9200	-1.5683	-0.6496	247.5	3.848	25.029	0.1537
12.9200	-1.6144	-0.5246	252.0	3.919	25.027	0.1566
12.9200	-1.6506	-0.3963	256.5	3.996	25.031	0.1596
12.9200	-1.6766	-0.2655	261.0	4.073	25.032	0.1627
12.9200	-1.6923	-0.1332	265.5	4.064	25.027	0.1624
12.9200	-1.6975	-0.0000	270.0	4.070	25.027	0.1626
12.9200	-1.6923	0.1332	274.5	4.052	25.026	0.1619
12.9200	-1.6766	0.2655	279.0	3.963	25.034	0.1583
12.9200	-1.6506	0.3963	283.5	3.825	25.035	0.1528
12.9200	-1.6144	0.5246	288.0	3.730	25.039	0.1490
12.9200	-1.5683	0.6496	292.5	3.721	25.033	0.1487
12.9200	-1.5125	0.7706	297.0	3.648	25.051	0.1456
12.9200	-1.4474	0.8869	301.5	3.622	25.046	0.1446
12.9200	-1.3733	0.9978	306.0	3.585	25.049	0.1431
12.9200	-1.2908	1.1024	310.5	3.599	25.052	0.1437
12.9200	-1.2003	1.2003	315.0	3.708	25.044	0.1481
12.9200	-1.1024	1.2908	319.5	3.847	25.042	0.1536
12.9200	-0.9978	1.3733	324.0	4.163	25.037	0.1663
12.9200	-0.8869	1.4474	328.5	4.502	25.050	0.1797
12.9200	-0.7706	1.5125	333.0	4.137	25.042	0.1652
12.9200	-0.6496	1.5683	337.5	3.537	25.046	0.1412
12.9200	-0.5246	1.6144	342.0	2.785	25.049	0.1112
12.9200	-0.3963	1.6506	346.5	2.384	25.052	0.0952
12.9200	-0.2655	1.6766	351.0	1.816	25.056	0.0725
12.9200	-0.1332	1.6923	355.5	1.774	25.048	0.0708
12.9200	0.0000	1.6975	360.0	0.991	25.051	0.0396
999.99	999.99	999.99	999.9	999.9	999.99	999.99

DATA FILE: SOR1PB DATE:26-FEB-87
OUTSIDE BODY VORTICES, INSIDE TIP VORTEX
YAW ANGLE=14.0 XM FROM BOW=12.92

XM	YM	ZM	ROTATION	VLASER	VFREE	RATIO	PERCENT
12.9200	0.0000	2.3475	0.0	1.363	24.992	0.0545	
12.9200	0.1842	2.3403	4.5	1.048	25.004	0.0419	
12.9200	0.3672	2.3186	9.0	0.773	24.997	0.0309	
12.9200	0.5480	2.2826	13.5	0.579	25.003	0.0232	
12.9200	0.7254	2.2326	18.0	0.310	25.011	0.0124	
12.9200	0.8983	2.1688	22.5	0.128	25.018	0.0051	
12.9200	1.0657	2.0916	27.0	-0.012	25.051	-0.0005	
12.9200	1.2266	2.0016	31.5	0.032	25.087	0.0013	
12.9200	1.3798	1.8992	36.0	-0.051	25.116	-0.0020	
12.9200	1.5246	1.7851	40.5	0.038	25.134	0.0015	
12.9200	1.6599	1.6599	45.0	0.168	25.173	0.0067	
12.9200	1.7851	1.5246	49.5	0.268	25.188	0.0106	
12.9200	1.8992	1.3798	54.0	0.754	25.198	0.0299	
12.9200	2.0016	1.2266	58.5	1.379	25.207	0.0547	
12.9200	2.0916	1.0657	63.0	2.828	25.210	0.1122	
12.9200	2.1688	0.8983	67.5	4.694	25.219	0.1861	
12.9200	2.2326	0.7254	72.0	5.756	25.229	0.2281	
12.9200	2.2826	0.5480	76.5	4.357	25.237	0.1726	
12.9200	2.3186	0.3672	81.0	1.978	25.261	0.0783	
12.9200	2.3403	0.1842	85.5	0.817	25.275	0.0323	
12.9200	2.3475	0.0000	90.0	0.105	25.274	0.0042	
12.9200	2.3403	-0.1842	94.5	-0.038	25.278	-0.0015	
12.9200	2.3186	-0.3672	99.0	-0.322	25.285	-0.0127	
12.9200	2.2826	-0.5480	103.5	-0.440	25.281	-0.0174	
12.9200	2.2326	-0.7254	108.0	-0.504	25.296	-0.0199	
12.9200	2.1688	-0.8983	112.5	-0.501	25.304	-0.0198	
12.9200	2.0916	-1.0657	117.0	-0.509	25.295	-0.0201	
12.9200	2.0016	-1.2266	121.5	-0.529	25.303	-0.0209	
12.9200	1.8992	-1.3798	126.0	-0.530	25.327	-0.0209	
12.9200	1.7851	-1.5246	130.5	-0.556	25.318	-0.0220	
12.9200	1.6599	-1.6599	135.0	-0.519	25.323	-0.0205	
12.9200	1.5246	-1.7851	139.5	-0.442	25.317	-0.0175	
12.9200	1.3798	-1.8992	144.0	-0.405	25.310	-0.0160	
12.9200	1.2266	-2.0016	148.5	-0.339	25.305	-0.0134	
12.9200	1.0657	-2.0916	153.0	-0.210	25.304	-0.0083	
12.9200	0.8983	-2.1688	157.5	-0.174	25.313	-0.0069	
12.9200	0.7254	-2.2326	162.0	-0.076	25.297	-0.0030	
12.9200	0.5480	-2.2826	166.5	0.082	25.284	0.0033	
12.9200	0.3672	-2.3186	171.0	0.234	25.283	0.0092	
12.9200	0.1842	-2.3403	175.5	0.333	25.288	0.0132	
12.9200	0.0000	-2.3475	180.0	0.473	25.290	0.0187	
12.9200	-0.1842	-2.3403	184.5	0.605	25.123	0.0241	
12.9200	-0.3672	-2.3186	189.0	0.705	25.107	0.0281	
12.9200	-0.5480	-2.2826	193.5	0.821	25.108	0.0327	
12.9200	-0.7254	-2.2326	198.0	1.000	25.100	0.0399	
12.9200	-0.8983	-2.1688	202.5	1.109	25.101	0.0442	
12.9200	-1.0657	-2.0916	207.0	1.249	25.103	0.0497	
12.9200	-1.2266	-2.0016	211.5	1.374	25.098	0.0547	
12.9200	-1.3798	-1.8992	216.0	1.474	25.097	0.0587	
12.9200	-1.5246	-1.7851	220.5	1.613	25.096	0.0643	
12.9200	-1.6599	-1.6599	225.0	1.620	25.089	0.0646	
12.9200	-1.7851	-1.5246	229.5	1.691	25.097	0.0674	
12.9200	-1.8992	-1.3798	234.0	1.863	25.079	0.0743	

12.9200	-2.0016	-1.2266	238.5	1.909	25.092	0.0761
12.9200	-2.0916	-1.0657	243.0	1.908	25.095	0.0760
12.9200	-2.1688	-0.8983	247.5	2.025	25.089	0.0807
12.9200	-2.2326	-0.7254	252.0	2.106	25.099	0.0839
12.9200	-2.2826	-0.5480	256.5	2.078	25.085	0.0828
12.9200	-2.3186	-0.3672	261.0	2.087	25.091	0.0832
12.9200	-2.3403	-0.1842	265.5	2.117	25.092	0.0844
12.9200	-2.3475	-0.0000	270.0	2.042	25.073	0.0814
12.9200	-2.3403	0.1842	274.5	2.127	25.076	0.0848
12.9200	-2.3186	0.3672	279.0	2.163	25.082	0.0862
12.9200	-2.2826	0.5480	283.5	2.189	25.089	0.0872
12.9200	-2.2326	0.7254	288.0	2.146	25.093	0.0855
12.9200	-2.1688	0.8983	292.5	2.145	25.086	0.0855
12.9200	-2.0916	1.0657	297.0	2.102	25.090	0.0838
12.9200	-2.0016	1.2266	301.5	2.073	25.085	0.0826
12.9200	-1.8992	1.3798	306.0	2.113	25.099	0.0842
12.9200	-1.7851	1.5246	310.5	2.203	25.113	0.0877
12.9200	-1.6599	1.6599	315.0	2.299	25.111	0.0915
12.9200	-1.5246	1.7851	319.5	2.401	25.109	0.0956
12.9200	-1.3798	1.8992	324.0	2.395	25.119	0.0953
12.9200	-1.2266	2.0016	328.5	2.547	25.116	0.1014
12.9200	-1.0657	2.0916	333.0	2.546	25.126	0.1013
12.9200	-0.8984	2.1688	337.5	2.463	25.121	0.0980
12.9200	-0.7254	2.2326	342.0	2.345	25.125	0.0933
12.9200	-0.5480	2.2826	346.5	2.237	25.133	0.0890
12.9200	-0.3672	2.3186	351.0	1.922	25.128	0.0765
12.9200	-0.1842	2.3403	355.5	1.578	25.112	0.0628
12.9200	0.0000	2.3475	360.0	1.391	25.121	0.0554
999.99	999.99	999.99	999.9	999.9	999.99	999.99

DATA FILE: SOOUTB DATE:25-FEB-87
TO RECHECK ZERO
YAW ANGLE=14.0 XM FROM BOW=12.92

XM	YM	ZM	ROTATION	VLASER	VFREE	RATIO	PERCENT
12.9200	0.0000	3.5665	0.0	0.392	25.051	0.0157	
12.9200	0.2798	3.5555	4.5	0.320	25.034	0.0128	
12.9200	0.5579	3.5226	9.0	0.219	25.009	0.0088	
12.9200	0.8326	3.4680	13.5	0.132	24.981	0.0053	
12.9200	1.1021	3.3919	18.0	0.071	25.004	0.0028	
12.9200	1.3648	3.2950	22.5	-0.063	25.009	-0.0025	
12.9200	1.6192	3.1778	27.0	-0.236	25.009	-0.0094	
12.9200	1.8635	3.0409	31.5	-0.335	25.021	-0.0134	
12.9200	2.0963	2.8854	36.0	-0.452	25.036	-0.0181	
12.9200	2.3163	2.7120	40.5	-0.657	25.042	-0.0262	
12.9200	2.5219	2.5219	45.0	-0.814	25.042	-0.0325	
12.9200	2.7120	2.3163	49.5	-0.996	25.044	-0.0398	
12.9200	2.8854	2.0963	54.0	-1.435	25.047	-0.0573	
12.9200	3.0409	1.8635	58.5	-1.894	25.059	-0.0756	
12.9200	3.1778	1.6192	63.0	-2.628	25.053	-0.1049	
12.9200	3.2950	1.3648	67.5	-3.276	25.058	-0.1307	
12.9200	3.3919	1.1021	72.0	-3.451	25.057	-0.1377	
12.9200	3.4680	0.8326	76.5	-3.088	25.051	-0.1233	
12.9200	3.5226	0.5579	81.0	-2.581	25.063	-0.1030	
12.9200	3.5555	0.2798	85.5	-2.127	25.075	-0.0848	
12.9200	3.5665	0.0000	90.0	-1.709	25.071	-0.0682	
12.9200	3.5555	-0.2798	94.5	-1.402	25.083	-0.0559	
12.9200	3.5226	-0.5579	99.0	-1.168	25.089	-0.0466	
12.9200	3.4680	-0.8326	103.5	-0.931	25.095	-0.0371	
12.9200	3.3919	-1.1021	108.0	-0.786	25.105	-0.0313	
12.9200	3.2950	-1.3648	112.5	-0.697	25.102	-0.0278	
12.9200	3.1778	-1.6192	117.0	-0.674	25.115	-0.0268	
12.9200	3.0409	-1.8635	121.5	-0.570	25.115	-0.0227	
12.9200	2.8854	-2.0963	126.0	-0.490	25.125	-0.0195	
12.9200	2.7120	-2.3163	130.5	-0.479	25.140	-0.0190	
12.9200	2.5219	-2.5219	135.0	-0.435	25.147	-0.0173	
12.9200	2.3163	-2.7120	139.5	-0.356	25.154	-0.0141	
12.9200	2.0963	-2.8854	144.0	-0.252	25.137	-0.0100	
12.9200	1.8635	-3.0409	148.5	-0.259	25.147	-0.0103	
12.9200	1.6192	-3.1778	153.0	-0.131	25.154	-0.0052	
12.9200	1.3648	-3.2950	157.5	-0.153	25.156	-0.0061	
12.9200	1.1021	-3.3919	162.0	-0.037	25.155	-0.0015	
12.9200	0.8326	-3.4680	166.5	0.028	25.142	0.0011	
12.9200	0.5579	-3.5226	171.0	0.062	25.155	0.0024	
12.9200	0.2798	-3.5555	175.5	0.116	25.156	0.0047	
12.9200	0.0000	-3.5665	180.0	0.186	25.162	0.0074	
12.9200	-0.2798	-3.5555	184.5	0.212	25.170	0.0084	
12.9200	-0.5579	-3.5226	189.0	0.298	25.166	0.0118	
12.9200	-0.8326	-3.4680	193.5	0.346	25.172	0.0137	
12.9200	-1.1021	-3.3919	198.0	0.427	25.160	0.0170	
12.9200	-1.3648	-3.2950	202.5	0.479	25.164	0.0190	
12.9200	-1.6192	-3.1778	207.0	0.577	25.176	0.0229	
12.9200	-1.8635	-3.0409	211.5	0.592	25.168	0.0235	
12.9200	-2.0963	-2.8854	216.0	0.656	25.170	0.0261	
12.9200	-2.3163	-2.7120	220.5	0.682	25.182	0.0271	
12.9200	-2.5219	-2.5219	225.0	0.731	25.087	0.0291	
12.9200	-2.7120	-2.3163	229.5	0.750	25.076	0.0299	
12.9200	-2.8854	-2.0963	234.0	0.760	25.086	0.0303	

12.9200	-3.0409	-1.8635	238.5	0.806	25.087	0.0321
12.9200	-3.1778	-1.6192	243.0	0.804	25.087	0.0320
12.9200	-3.2950	-1.3648	247.5	0.871	25.088	0.0347
12.9200	-3.3919	-1.1021	252.0	0.912	25.098	0.0363
12.9200	-3.4680	-0.8326	256.5	0.966	25.096	0.0385
12.9200	-3.5226	-0.5579	261.0	0.922	25.095	0.0367
12.9200	-3.5555	-0.2798	265.5	0.934	25.096	0.0372
12.9200	-3.5665	-0.0000	270.0	0.939	25.091	0.0374
12.9200	-3.5555	0.2798	274.5	0.935	25.108	0.0372
12.9200	-3.5226	0.5579	279.0	0.992	25.110	0.0395
12.9200	-3.4680	0.8326	283.5	1.019	25.116	0.0406
12.9200	-3.3919	1.1021	288.0	0.980	25.115	0.0390
12.9200	-3.2950	1.3648	292.5	0.883	25.109	0.0352
12.9200	-3.1778	1.6192	297.0	0.949	25.114	0.0378
12.9200	-3.0409	1.8635	301.5	1.011	25.129	0.0402
12.9200	-2.8854	2.0963	306.0	1.017	25.114	0.0405
12.9200	-2.7120	2.3163	310.5	1.070	25.132	0.0426
12.9200	-2.5219	2.5219	315.0	1.034	25.125	0.0412
12.9200	-2.3163	2.7120	319.5	1.034	25.127	0.0411
12.9200	-2.0963	2.8854	324.0	0.933	25.133	0.0371
12.9200	-1.8635	3.0409	328.5	0.922	25.125	0.0367
12.9200	-1.6192	3.1778	333.0	0.870	25.129	0.0346
12.9200	-1.3648	3.2950	337.5	0.850	25.143	0.0338
12.9200	-1.1021	3.3919	342.0	0.808	25.144	0.0321
12.9200	-0.8326	3.4680	346.5	0.674	25.148	0.0268
12.9200	-0.5579	3.5226	351.0	0.596	25.152	0.0237
12.9200	-0.2798	3.5555	355.5	0.476	25.159	0.0189
12.9200	0.0000	3.5665	360.0	0.410	25.155	0.0163
999.99	999.99	999.99	999.9	999.99	999.99	999.99

APPENDIX 9

DATA FILE: VPP2 DATE:25-FEB-87
.2° FROM TIP--POSITIVE VERTICAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
-0.2000	-0.4500	0.2000	-4.025	25.054	-0.1606
-0.2000	-0.3500	0.2000	-4.703	24.993	-0.1882
-0.2000	-0.2500	0.2000	-5.388	24.959	-0.2159
-0.2000	-0.1500	0.2000	-5.691	24.909	-0.2285
-0.2000	-0.0500	0.2000	-4.914	24.895	-0.1974
-0.2000	0.0500	0.2000	-3.147	24.883	-0.1265
-0.2000	0.1500	0.2000	-1.513	24.862	-0.0609
-0.2000	0.2500	0.2000	-0.599	24.866	-0.0241
-0.2000	0.3500	0.2000	-0.097	24.865	-0.0039
-0.2000	0.4500	0.2000	0.106	24.851	0.0043
-0.2000	0.5500	0.2000	0.155	24.859	0.0063
-0.2000	0.6500	0.2000	0.216	24.856	0.0087
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: VMP2 DATE:25-FEB-87
.2° FROM TIP--NEGATIVE VERTICAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
2.2000	0.6500	0.2000	-2.589	24.929	-0.1039
2.2000	0.5500	0.2000	-3.750	24.909	-0.1505
2.2000	0.4500	0.2000	-9.967	24.883	-0.4006
2.2000	0.3500	0.2000	-8.243	24.831	-0.3320
2.2000	0.2500	0.2000	5.911	24.816	0.2382
2.2000	0.1500	0.2000	1.369	24.814	0.0552
2.2000	0.0500	0.2000	1.228	24.811	0.0495
2.2000	-0.0500	0.2000	1.150	24.807	0.0463
2.2000	-0.1500	0.2000	1.207	24.811	0.0487
2.2000	-0.2500	0.2000	1.078	24.807	0.0435
2.2000	-0.3500	0.2000	1.101	24.808	0.0444
2.2000	-0.4500	0.2000	1.047	24.815	0.0422
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: HPP2 DATE:27-FEB-87
.2° FROM TIP--POSITIVE VERTICAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
-0.2000	0.6500	0.2000	23.901	25.116	0.9516
-0.1000	0.6500	0.2000	23.894	25.108	0.9516
0.0000	0.6500	0.2000	24.039	25.079	0.9586
0.1000	0.6500	0.2000	24.271	25.055	0.9687
0.2000	0.6500	0.2000	24.519	25.063	0.9783
0.3000	0.6500	0.2000	24.960	25.044	0.9966
0.4000	0.6500	0.2000	25.328	25.055	1.0109
0.5000	0.6500	0.2000	25.672	25.039	1.0253
0.6000	0.6500	0.2000	25.937	25.028	1.0363
0.7000	0.6500	0.2000	26.329	25.035	1.0517
0.8000	0.6500	0.2000	26.491	25.031	1.0583
0.9000	0.6500	0.2000	26.685	25.009	1.0670
1.0000	0.6500	0.2000	26.777	25.010	1.0706
1.1000	0.6500	0.2000	26.856	25.005	1.0740
1.2000	0.6500	0.2000	26.766	25.002	1.0705
1.3000	0.6500	0.2000	26.743	24.996	1.0699
1.4000	0.6500	0.2000	26.693	24.984	1.0684
1.5000	0.6500	0.2000	26.785	24.979	1.0723
1.6000	0.6500	0.2000	26.554	24.977	1.0632
1.7000	0.6500	0.2000	26.239	24.985	1.0502
1.8000	0.6500	0.2000	26.030	24.979	1.0421
1.9000	0.6500	0.2000	25.736	24.961	1.0310
2.0000	0.6500	0.2000	25.543	24.973	1.0229
2.1000	0.6500	0.2000	25.301	24.979	1.0129
2.2000	0.6500	0.2000	25.223	24.975	1.0099
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: HMP2 DATE:27-FEB-87
.2° FROM TIP--NEGATIVE HORIZONTAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
2.2000	-0.4500	0.2000	25.853	25.118	1.0293
2.1000	-0.4500	0.2000	25.923	25.065	1.0342
2.0000	-0.4500	0.2000	26.000	25.070	1.0371
1.9000	-0.4500	0.2000	26.089	25.055	1.0413
1.8000	-0.4500	0.2000	26.222	25.026	1.0478
1.7000	-0.4500	0.2000	26.285	25.001	1.0514
1.6000	-0.4500	0.2000	26.421	25.002	1.0567
1.5000	-0.4500	0.2000	26.618	24.987	1.0653
1.4000	-0.4500	0.2000	26.812	24.980	1.0733
1.3000	-0.4500	0.2000	27.153	24.982	1.0869
1.2000	-0.4500	0.2000	27.358	24.971	1.0956
1.1000	-0.4500	0.2000	27.557	24.959	1.1041
1.0000	-0.4500	0.2000	27.883	24.964	1.1170
0.9000	-0.4500	0.2000	28.263	24.958	1.1324
0.8000	-0.4500	0.2000	28.691	24.953	1.1498
0.7000	-0.4500	0.2000	29.143	24.952	1.1680
0.6000	-0.4500	0.2000	29.590	24.955	1.1857
0.5000	-0.4500	0.2000	29.997	24.947	1.2024
0.4000	-0.4500	0.2000	30.199	24.950	1.2103
0.3000	-0.4500	0.2000	30.156	24.940	1.2091
0.2000	-0.4500	0.2000	29.731	24.947	1.1918
0.1000	-0.4500	0.2000	28.924	24.943	1.1596
0.0000	-0.4500	0.2000	27.903	24.940	1.1188
-0.1000	-0.4500	0.2000	26.961	24.942	1.0810
-0.2000	-0.4500	0.2000	26.297	24.937	1.0545
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: VPF45 DATE:25-FEB-87
.45" FROM TIP--POSITIVE VERTICAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
-0.2000	-0.4500	0.4500	-4.882	25.091	-0.1946
-0.2000	-0.3500	0.4500	-5.882	25.028	-0.2350
-0.2000	-0.2500	0.4500	-6.919	24.974	-0.2771
-0.2000	-0.1500	0.4500	-7.288	24.951	-0.2921
-0.2000	-0.0500	0.4500	-6.230	24.931	-0.2499
-0.2000	0.0500	0.4500	-3.810	24.914	-0.1529
-0.2000	0.1500	0.4500	-1.611	24.905	-0.0647
-0.2000	0.2500	0.4500	-0.271	24.898	-0.0109
-0.2000	0.3500	0.4500	0.312	24.886	0.0125
-0.2000	0.4500	0.4500	0.513	24.884	0.0206
-0.2000	0.5500	0.4500	0.584	24.879	0.0235
-0.2000	0.6500	0.4500	0.643	24.862	0.0258
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: VMF45 DATE:25-FEB-87
.45" FROM TIP--NEGATIVE VERTICAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
2.2000	0.6500	0.4500	1.612	25.086	0.0643
2.2000	0.5500	0.4500	3.652	25.032	0.1459
2.2000	0.4500	0.4500	7.659	25.015	0.3062
2.2000	0.3500	0.4500	9.501	24.998	0.3801
2.2000	0.2500	0.4500	8.676	24.978	0.3473
2.2000	0.1500	0.4500	6.955	24.947	0.2788
2.2000	0.0500	0.4500	5.381	24.936	0.2158
2.2000	-0.0500	0.4500	4.221	24.934	0.1693
2.2000	-0.1500	0.4500	3.536	24.930	0.1418
2.2000	-0.2500	0.4500	2.861	24.913	0.1149
2.2000	-0.3500	0.4500	2.539	24.914	0.1019
2.2000	-0.4500	0.4500	2.221	24.922	0.0891
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: HPP45 DATE:27-FEB-87
.45° FROM TIP--POSITIVE HORIZONTAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
-0.2000	0.6500	0.4500	23.101	25.058	0.9219
-0.1000	0.6500	0.4500	23.174	25.053	0.9250
0.0000	0.6500	0.4500	23.358	25.052	0.9324
0.1000	0.6500	0.4500	23.722	25.062	0.9465
0.2000	0.6500	0.4500	23.979	25.071	0.9564
0.3000	0.6500	0.4500	24.455	25.066	0.9756
0.4000	0.6500	0.4500	24.855	25.075	0.9912
0.5000	0.6500	0.4500	25.341	25.075	1.0106
0.6000	0.6500	0.4500	25.634	25.074	1.0223
0.7000	0.6500	0.4500	25.894	25.057	1.0334
0.8000	0.6500	0.4500	26.227	25.084	1.0456
0.9000	0.6500	0.4500	26.496	25.074	1.0567
1.0000	0.6500	0.4500	26.612	25.080	1.0611
1.1000	0.6500	0.4500	26.643	25.086	1.0621
1.2000	0.6500	0.4500	26.679	25.079	1.0638
1.3000	0.6500	0.4500	26.516	25.081	1.0572
1.4000	0.6500	0.4500	26.510	25.078	1.0571
1.5000	0.6500	0.4500	26.431	25.085	1.0537
1.6000	0.6500	0.4500	26.370	25.082	1.0514
1.7000	0.6500	0.4500	26.068	25.070	1.0398
1.8000	0.6500	0.4500	25.674	25.065	1.0243
1.9000	0.6500	0.4500	25.310	25.068	1.0096
2.0000	0.6500	0.4500	24.787	25.063	0.9890
2.1000	0.6500	0.4500	24.575	25.066	0.9804
2.2000	0.6500	0.4500	24.556	25.073	0.9794
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: HMP45 DATE:27-FEB-87
.45° FROM TIP--NEGATIVE HORIZONTAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
2.2000	-0.4500	0.4500	25.866	25.103	1.0304
2.1000	-0.4500	0.4500	25.979	25.080	1.0358
2.0000	-0.4500	0.4500	26.124	25.082	1.0415
1.9000	-0.4500	0.4500	26.161	25.079	1.0431
1.8000	-0.4500	0.4500	26.330	25.065	1.0505
1.7000	-0.4500	0.4500	26.412	25.054	1.0542
1.6000	-0.4500	0.4500	26.604	25.049	1.0621
1.5000	-0.4500	0.4500	26.810	25.048	1.0703
1.4000	-0.4500	0.4500	27.030	25.026	1.0801
1.3000	-0.4500	0.4500	27.283	25.031	1.0900
1.2000	-0.4500	0.4500	27.631	25.032	1.1038
1.1000	-0.4500	0.4500	27.988	25.021	1.1186
1.0000	-0.4500	0.4500	28.341	25.020	1.1327
0.9000	-0.4500	0.4500	28.795	25.021	1.1508
0.8000	-0.4500	0.4500	29.309	25.010	1.1719
0.7000	-0.4500	0.4500	29.900	25.001	1.1960
0.6000	-0.4500	0.4500	30.446	25.008	1.2175
0.5000	-0.4500	0.4500	31.060	25.008	1.2420
0.4000	-0.4500	0.4500	31.434	25.010	1.2569
0.3000	-0.4500	0.4500	31.486	25.008	1.2591
0.2000	-0.4500	0.4500	31.053	25.001	1.2421
0.1000	-0.4500	0.4500	30.010	24.991	1.2008
0.0000	-0.4500	0.4500	28.678	24.997	1.1472
-0.1000	-0.4500	0.4500	27.430	24.990	1.0977
-0.2000	-0.4500	0.4500	26.522	24.994	1.0611
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: VPP7 DATE:25-FEB-87
.7" FROM TIP--POSITIVE VERTICAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
-0.2000	-0.4500	0.7000	-5.579	25.106	-0.2222
-0.2000	-0.3500	0.7000	-6.685	25.057	-0.2668
-0.2000	-0.2500	0.7000	-7.758	24.991	-0.3104
-0.2000	-0.1500	0.7000	-8.296	24.962	-0.3323
-0.2000	-0.0500	0.7000	-7.060	24.931	-0.2832
-0.2000	0.0500	0.7000	-4.442	24.921	-0.1782
-0.2000	0.1500	0.7000	-1.998	24.902	-0.0802
-0.2000	0.2500	0.7000	-0.492	24.894	-0.0198
-0.2000	0.3500	0.7000	0.286	24.890	0.0115
-0.2000	0.4500	0.7000	0.588	24.870	0.0236
-0.2000	0.5500	0.7000	0.720	24.869	0.0290
-0.2000	0.6500	0.7000	0.860	24.877	0.0346
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: VMP7 DATE:25-FEB-87
.7" FROM TIP--NEGATIVE VERTICAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
2.2000	0.6500	0.7000	1.679	24.996	0.0672
2.2000	0.5500	0.7000	2.336	24.960	0.0936
2.2000	0.4500	0.7000	3.326	24.970	0.1332
2.2000	0.3500	0.7000	6.393	24.954	0.2562
2.2000	0.2500	0.7000	6.713	24.947	0.2691
2.2000	0.1500	0.7000	6.403	24.937	0.2568
2.2000	0.0500	0.7000	5.810	24.922	0.2331
2.2000	-0.0500	0.7000	5.087	24.904	0.2043
2.2000	-0.1500	0.7000	4.443	24.899	0.1785
2.2000	-0.2500	0.7000	3.814	24.894	0.1532
2.2000	-0.3500	0.7000	3.329	24.899	0.1337
2.2000	-0.4500	0.7000	2.963	24.888	0.1191
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: HFF7 DATE:26-FEB-87
.7° FROM TIP

XS	YS	ZS	VLASER	VFREE	RATIO
-0.2000	0.6500	0.7000	22.802	25.116	0.9079
-0.1000	0.6500	0.7000	22.787	25.109	0.9075
0.0000	0.6500	0.7000	22.913	25.093	0.9131
0.1000	0.6500	0.7000	23.306	25.084	0.9291
0.2000	0.6500	0.7000	23.638	25.075	0.9427
0.3000	0.6500	0.7000	23.999	25.068	0.9573
0.4000	0.6500	0.7000	24.432	25.071	0.9745
0.5000	0.6500	0.7000	24.955	25.064	0.9957
0.6000	0.6500	0.7000	25.367	25.067	1.0120
0.7000	0.6500	0.7000	25.687	25.054	1.0253
0.8000	0.6500	0.7000	26.042	25.054	1.0394
0.9000	0.6500	0.7000	26.229	25.052	1.0470
1.0000	0.6500	0.7000	26.346	25.058	1.0514
1.1000	0.6500	0.7000	26.415	25.052	1.0544
1.2000	0.6500	0.7000	26.499	25.039	1.0583
1.3000	0.6500	0.7000	26.331	25.028	1.0520
1.4000	0.6500	0.7000	26.332	25.027	1.0522
1.5000	0.6500	0.7000	26.123	25.022	1.0440
1.6000	0.6500	0.7000	26.126	25.020	1.0442
1.7000	0.6500	0.7000	25.852	25.018	1.0334
1.8000	0.6500	0.7000	25.580	25.024	1.0222
1.9000	0.6500	0.7000	25.189	25.015	1.0070
2.0000	0.6500	0.7000	24.694	25.020	0.9869
2.1000	0.6500	0.7000	24.319	25.008	0.9724
2.2000	0.6500	0.7000	24.324	25.007	0.9727
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: HMF7 DATE:27-FEB-87
.7° FROMTIP--NEGATIVE HORIZONTAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
2.2000	-0.4500	0.7000	25.959	25.063	1.0358
2.1000	-0.4500	0.7000	26.034	25.046	1.0395
2.0000	-0.4500	0.7000	26.253	25.042	1.0484
1.9000	-0.4500	0.7000	26.412	25.042	1.0547
1.8000	-0.4500	0.7000	26.597	25.009	1.0635
1.7000	-0.4500	0.7000	[illegible]	[illegible]	1.0691
1.6000	-0.4500	0.7000	26.971	25.021	1.0780
1.5000	-0.4500	0.7000	27.192	25.011	1.0872
1.4000	-0.4500	0.7000	27.409	25.000	1.0963
1.3000	-0.4500	0.7000	27.701	25.016	1.1073
1.2000	-0.4500	0.7000	27.940	24.988	1.1181
1.1000	-0.4500	0.7000	28.254	24.990	1.1306
1.0000	-0.4500	0.7000	28.658	24.976	1.1474
0.9000	-0.4500	0.7000	[illegible]	[illegible]	1.1658
0.8000	-0.4500	0.7000	[illegible]	[illegible]	[illegible]
0.7000	-0.4500	0.7000	[illegible]	[illegible]	[illegible]
0.6000	-0.4500	0.7000	30.911	24.961	1.2383
0.5000	-0.4500	0.7000	31.481	[illegible]	1.2618
0.4000	-0.4500	0.7000	[illegible]	24.962	1.2830
0.3000	-0.4500	0.7000	32.047	24.961	1.2841
0.2000	-0.4500	0.7000	31.656	24.971	1.2678
0.1000	-0.4500	0.7000	[illegible]	24.959	[illegible]
0.0000	-0.4500	0.7000	29.041	24.951	1.1641
-0.1000	-0.4500	0.7000	[illegible]	24.953	1.1085
-0.2000	-0.4500	0.7000	[illegible]	[illegible]	1.0668
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: HF1F2

1.2" FROM TIP--POSITIVE HORIZONTAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
-0.2000	0.6500	1.2000	22.494	25.067	0.8974
-0.1000	0.6500	1.2000	22.652	25.086	0.9030
0.0000	0.6500	1.2000	22.498	25.089	0.8967
0.1000	0.6500	1.2000	22.844	25.099	0.9102
0.2000	0.6500	1.2000	23.271	25.105	0.9269
0.3000	0.6500	1.2000	23.724	25.119	0.9445
0.4000	0.6500	1.2000	22.863	25.116	0.9103
0.5000	0.6500	1.2000	17.973	25.126	0.7153
0.6000	0.6500	1.2000	25.219	25.143	1.0030
0.7000	0.6500	1.2000	25.445	25.103	1.0136
0.8000	0.6500	1.2000	25.793	25.107	1.0273
0.9000	0.6500	1.2000	26.054	25.120	1.0372
1.0000	0.6500	1.2000	26.255	25.140	1.0444
1.1000	0.6500	1.2000	26.283	25.130	1.0459
1.2000	0.6500	1.2000	26.501	25.147	1.0538
1.3000	0.6500	1.2000	26.448	25.149	1.0516
1.4000	0.6500	1.2000	26.604	25.152	1.0577
1.5000	0.6500	1.2000	26.451	25.152	1.0516
1.6000	0.6500	1.2000	26.406	25.160	1.0495
1.7000	0.6500	1.2000	26.255	25.156	1.0437
1.8000	0.6500	1.2000	26.135	25.160	1.0388
1.9000	0.6500	1.2000	26.013	25.173	1.0334
2.0000	0.6500	1.2000	25.651	25.166	1.0193
2.1000	0.6500	1.2000	25.407	25.179	1.0090
2.2000	0.6500	1.2000	24.958	25.171	0.9916
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: HM1F2 DATE:27-FEB-87

1.2" FROM TIP-- NEGATIVE HORIZONTAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
2.2000	-0.4500	1.2000	26.018	25.055	1.0384
2.1000	-0.4500	1.2000	26.321	25.042	1.0511
2.0000	-0.4500	1.2000	26.674	25.041	1.0652
1.9000	-0.4500	1.2000	27.125	25.050	1.0828
1.8000	-0.4500	1.2000	27.547	25.021	1.1010
1.7000	-0.4500	1.2000	27.967	25.016	1.1180
1.6000	-0.4500	1.2000	28.368	25.020	1.1338
1.5000	-0.4500	1.2000	28.864	25.004	1.1544
1.4000	-0.4500	1.2000	29.268	24.996	1.1709
1.3000	-0.4500	1.2000	29.377	25.000	1.1751
1.2000	-0.4500	1.2000	29.567	24.988	1.1832
1.1000	-0.4500	1.2000	29.562	24.987	1.1831
1.0000	-0.4500	1.2000	29.554	24.975	1.1834
0.9000	-0.4500	1.2000	29.594	24.975	1.1849
0.8000	-0.4500	1.2000	29.680	24.969	1.1886
0.7000	-0.4500	1.2000	29.975	24.973	1.2003
0.6000	-0.4500	1.2000	30.460	24.966	1.2201
0.5000	-0.4500	1.2000	30.932	24.972	1.2387
0.4000	-0.4500	1.2000	31.433	24.966	1.2590
0.3000	-0.4500	1.2000	31.651	24.966	1.2678
0.2000	-0.4500	1.2000	31.385	24.966	1.2571
0.1000	-0.4500	1.2000	30.380	24.959	1.2172
0.0000	-0.4500	1.2000	29.033	24.962	1.1631
-0.1000	-0.4500	1.2000	27.681	24.951	1.1094
-0.2000	-0.4500	1.2000	26.636	24.943	1.0679
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: VP1P2 DATE:25-FEB-87
1.2' FROM TIP--POSITIVE VERTICAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
-0.2000	-0.4500	1.2000	-6.991	25.079	-0.2788
-0.2000	-0.3500	1.2000	-8.158	25.001	-0.3263
-0.2000	-0.2500	1.2000	-9.343	24.970	-0.3742
-0.2000	-0.1500	1.2000	-9.779	24.899	-0.3927
-0.2000	-0.0500	1.2000	-8.550	24.879	-0.3437
-0.2000	0.0500	1.2000	-5.763	24.870	-0.2317
-0.2000	0.1500	1.2000	-3.002	24.853	-0.1208
-0.2000	0.2500	1.2000	-1.217	24.850	-0.0490
-0.2000	0.3500	1.2000	-0.268	24.840	-0.0108
-0.2000	0.4500	1.2000	0.208	24.844	0.0084
-0.2000	0.5500	1.2000	0.498	24.848	0.0200
-0.2000	0.6500	1.2000	0.725	24.844	0.0292
999.99	999.99	999.99	999.99	999.99	999.99

DATA FILE: VM1P2 DATE:25-FEB-87
1.2' FROM TIP--NEGATIVE VERTICAL LEG

XS	YS	ZS	VLASER	VFREE	RATIO
2.2000	0.6500	1.2000	-0.034	25.026	-0.0013
2.2000	0.5500	1.2000	-0.632	25.021	-0.0252
2.2000	0.4500	1.2000	0.118	24.955	0.0047
2.2000	0.3500	1.2000	0.893	24.935	0.0358
2.2000	0.2500	1.2000	4.407	24.930	0.1768
2.2000	0.1500	1.2000	3.826	24.909	0.1536
2.2000	0.0500	1.2000	5.424	24.931	0.2176
2.2000	-0.0500	1.2000	5.449	24.946	0.2185
2.2000	-0.1500	1.2000	4.875	24.951	0.1954
2.2000	-0.2500	1.2000	4.521	24.952	0.1812
2.2000	-0.3500	1.2000	4.233	24.966	0.1695
2.2000	-0.4500	1.2000	3.781	24.964	0.1515
999.99	999.99	999.99	999.99	999.99	999.99

APPENDIX 10

THEORETICAL CALCULATIONS
(15 Degrees Yaw Angle)

From Wald [9,10]:

$$\frac{dC_L}{d\alpha} = .0505$$

$$\frac{dC_L}{d\alpha}(\alpha) = .7575$$

$$\rho U \bar{\Gamma} = C_L(\tfrac{1}{2}\rho U^2 S)$$

$$\bar{\Gamma} = C_L(\tfrac{1}{2}US)$$

To non-dimensionalize consistently throughout:

$$\Gamma = \frac{\bar{\Gamma}}{Uds} = 294$$

Where:

C_L: Coefficient of lift nondimensionalized as shown in third equation.

S: Planform area of fin.

$\bar{\Gamma}$: Spanwise integration of circulation across fin.

Γ: Circulation non-dimensionalized on freestream velocity and maximum body diameter.

s: Span of fin.

END
DATE
FILMED
FEB.
1988